SCIENTIFIC AMERICAN SUPPLEMENT No. 688

Scientific American Supplement, Vol. XXVII., No. 688.
Scientific American, established 1845.

NEW YORK, MARCH 9, 1889.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE SAMOAN ISLANDS.

WHEN the explorers of the Pacific Ocean discovered the charming group of Samoan Islands, that they compared to an Eden, they scarcely foresaw the events of which it is now the scene. For a little more than a year, troubles have been breaking out there at every instant. The aborigines are fighting the Germans, who, by virtue of special treaties, share the sovereignty of the country with England and the United States. That is the origin of the contest. Should we desire to get at the bottom of the thing, it would be quite difficult to find out. The Germans intend to have exclusive sway over the territories which vest in them.

On the other hand, the aborigines have their prejudices. They do not show these openly, but the aid that the United States are giving them is an indication of it. The quarrel began in September, 1887. At this epoch, it was learned that Germany had, by main force, carried off the King of Samoa, Malietoa Laupepa (called also Mataafa), put him on board of a ship of war, and sent him to the sands of New Guinea to meditate upon the inconveniences attached to royalty when the latter is exercised to the detriment of German influences.

Germany then protected and is still protecting viceroy Matasese, who is favorable to her. Nevertheless, as her co-subscribers to the treaty guaranteeing the independence of the Samoas had made representations to her, she had to submit to the agreement that stipulated that none of the three powers should raise any pretensions or attempt to usurp the island. But she had nevertheless made a king, Matasese, who has under him two thousand native warriors, while the partisans of Malietoa are four thousand in number. The conflicts between the two rival factions are incessant. It is unnecessary to say that the plantations are ravaged, and the lives of the Europeans placed in peril. More than a year ago, if we are to believe German documents, the partisans of Malietoa committed some acts of violence on the German settlers who were celebrating at Apia the anniversary of the birth of Emperor William I. It was as a consequence of such acts that five hundred men landed, and, proceeding to the city, proclaimed Matasese king of the archipelago.

The United States are now protesting. President Cleveland has just submitted the state of the question to Congress in a message in which he does not dissimulate his apprehensions on the subject of Germany's designs upon the independence guaranteed to the inhabitants of Samoa. As for England, she has allowed it to be understood that she consents to treat Matasese as king *de facto*, if not *de jure*.

These facts are attracting public attention to the Samoan Islands, and so we think that our readers will be glad to receive some information regarding this so little known group.

The Samoas, whose total area is 1,060 square miles, have, according to a census taken in 1871, a population of 31,265 inhabitants. To these figures must be added about 2,500, representing foreigners. The ports of these islands were officially opened to the commerce of Germany, England, and the United States in 1878, conformably to amicable treaties concluded by the native kings with these powers. These treaties guarantee the political independence of the Samoas. The Samoan archipelago comprises fourteen volcanic islands, the most important of which are Savaii, Opolu, Tutuila, and Manono. They are in communication with the exterior through the port of Pago-Pago, in the island of Tutuila, and that of Apia, in the island of Opolu. Other ports of less importance, such as that of Salonasata, are likewise open to commerce.

When the Samoas were discovered in 1768 by Bougainville, the male population was fierce, and it did not seem to be much improved even under American influence, which endowed it with a petty parliamentary government comprising a senate of five members selected from the families of the old chiefs, and a lower house of eighteen members. The government sits at Moulinauon, the capital of Samoa, which numbers about 800 inhabitants.

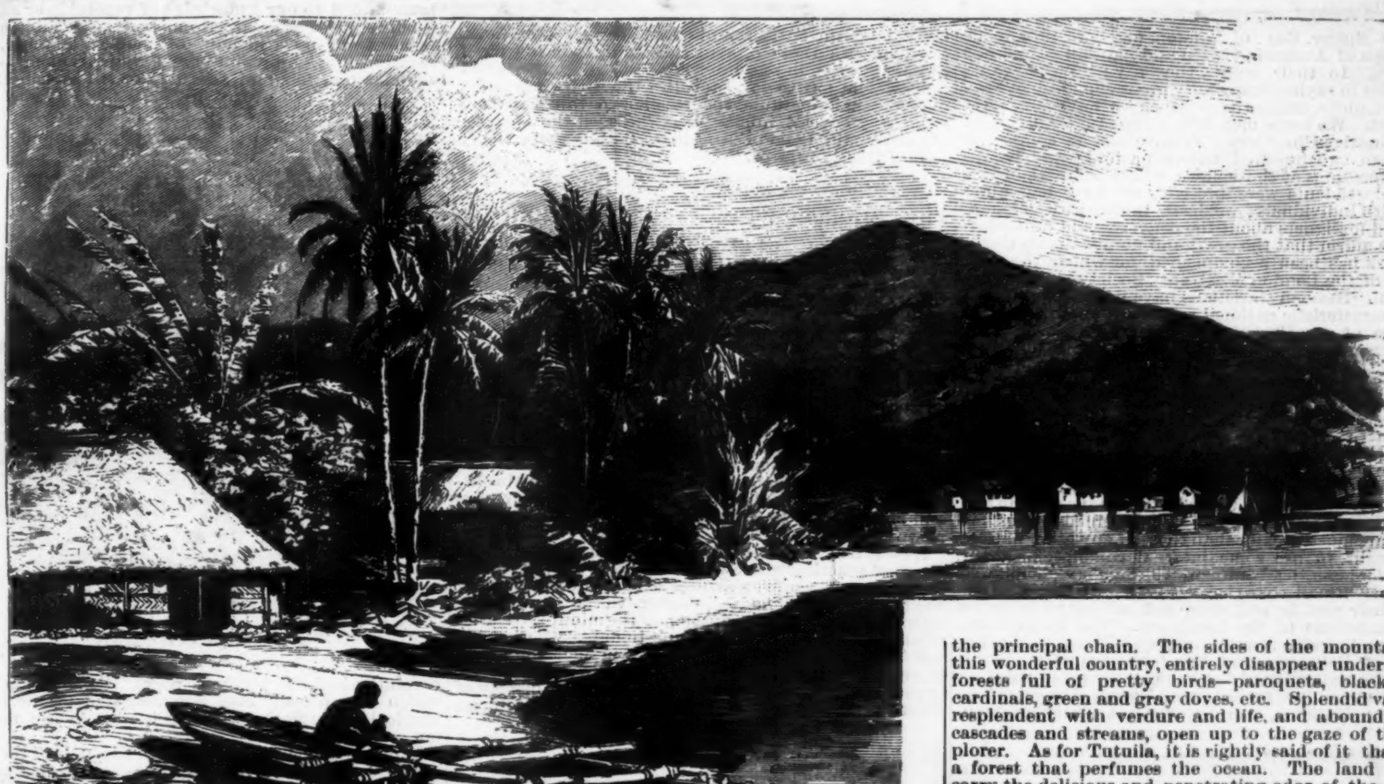
Although the Samoans attached to the glebe exhibit an entire absence of the prejudices concerning clothing, those who are closely or remotely connected with politics usually wear a black frock coat, polished boots and a silk hat. The women are agreeable and generally pretty. They are large, slender and graceful, but it is rare that this beauty resists the assaults of the twentieth year. They fade very quickly. They wear a costume that scarcely differs from that of the men—a girdle of seaweed or leaves falling in the form of a petticoat over the legs.

Bougainville, as we know, called the Samoas by the name of Navigators' Islands, because he was struck by the large number of pirogues that covered the sea upon his arrival. The Samoans, in fact, are excellent navigators. Their pirogues are such that fifty persons can be accommodated in them with ease. These boats, propelled by twenty-four oarsmen, are provided with a balance resting upon floating pieces of wood, which in case of wind serve as a bearing point to the pirogues, and prevent them from capsizing. The sail, consisting of several mats, is triangular. The huts are kept in perfect order, and the town house of Apia, for example, is remarkable. A row of columns, formed of tree trunks, forms the circumference of it. The roof frame, of original form, is covered externally with the leaves of the cocoanut tree.

At Apia, the resident consuls of Germany, England, and the United States have, with three assessors, constituted themselves a sort of town council, which watches over the interests of the Europeans, and holds the government in respect. At Opolu, some French ministers have founded an establishment and built a church, and, thanks to them, the name of France is there beloved and respected.

In the country, orange tree hedges border the foot paths, which lead with an easy ascent to the crests of the principal chain. The sides of the mountain, in this wonderful country, entirely disappear under dense forests full of pretty birds—paroquets, blackbirds, cardinals, green and gray doves, etc. Splendid valleys, resplendent with verdure and life, and abounding in cascades and streams, open up to the gaze of the explorer. As for Tutuila, it is rightly said of it that it is a forest that perfumes the ocean. The land winds carry the delicious and penetrating odor of the moussoal as far as to the bay of Pago-Pago. The most populous island, Savaii, is more hilly than its neighbors. The mountains there reach an altitude of 4,000 feet, and a number of streams are met with, that have cut a passage through the luxuriant vegetation of the immense forests. The surface is formed of huge rocks in which open unfathomable craters. The villages are situated in the midst of woods of palms and pines, and are protected against high winds by walls of tall fern trees.

Without any desire of interfering any more than is necessary in Samoan politics, it is permissible to say and believe that the Germans, having undertaken to become a great maritime nation, are, by installing themselves in these islands, taking measures to preserve points of supply for themselves in case the routes of the Pacific Ocean should some day be disputed with them.—*L'Illustration.*

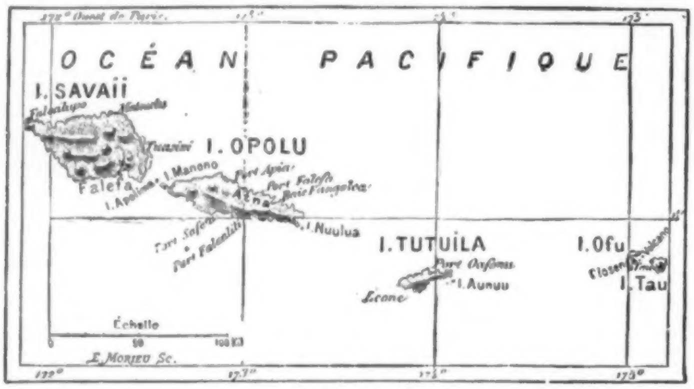


VIEW OF APIA, SAMOAN ISLANDS.

THE SAMOAN ISLANDS.

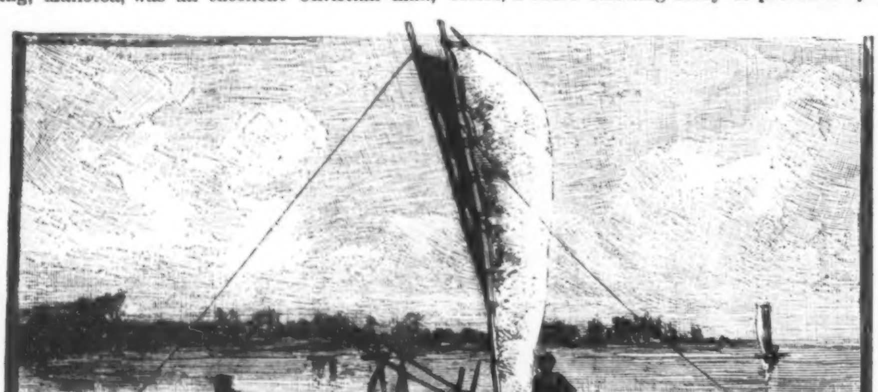
A RECENT number of the *Missionary Herald* contains the following: The world is hearing much about these islands in a political way, and our readers will be glad to know something of the missionary work therein. The Samoan group, sometimes called the Navigators, lies between latitude 13° 30' and 14° 30' south and longitude 169° and 173° west. Its chief islands are Savaii, Opolu, Tutuila, and Manua. The population is said to number from 30,000 to 35,000. Missionary work, initiated by John Williams, has been carried on in this group by the London Missionary Society for more than fifty years, and, though the returns are incomplete, the last report gives the number of church members as 3,714 and the adherents as 15,734. Besides this there is work in other groups, the Ellice, Tokelau, and Gilbert Islands, carried on from Samoa, reporting a church membership of 2,260. There are eight English missionaries located on Opolu and Savaii of the Samoan group, and 177 native ordained pastors. One of the chief agencies for the prosecution of missionary work is the institution for training native pastors at Malua, on the island of Opolu, which at last reports had 99 students. It is largely a self-sustaining institution, the

students cultivating land and raising their own food. There are other institutions at other islands, both for males and females, in which there is great enthusiasm on the part of the students. On the large island of Savaii there are six schools, which have a total membership of 1,332. As to the character of these native Christians, it may be said that while it could not be expected that they should be in all respects models of deportment, they bear the tests of discipleship fairly well. There are frequent lapses, and yet one missionary says that out of a church membership of 900 on Savaii, there have been only four cases of church discipline on account of drunkenness. Last year the London Missionary Society sent a special deputation to the Samoan Islands to examine the condition of its mission. A. Spicer, Esq., of London, and two prominent clergymen of Australia visited and carefully examined the work. In their report they say: "We have no hesitation in saying that a very great change has been wrought, and a change as great as we have any right to expect. We have met and addressed large assemblies of native Christians; we have met in conference more than two hundred native pastors; we have attended meetings at the college, where more than one hundred students were present; we have had quiet talks with individuals; we have talked with missionaries and foreigners about the converts, and unhesitatingly we affirm that the great and unmistakably Christian work has been accomplished, for which the supporters of the London Missionary Society may be very thankful. Samoan Christians have not yet conquered their characteristic national and social weaknesses, but the force of new Christian principles is felt, and the divine truths of the Gospel are transforming, by a sure process, the character of the people." The deputation also says: "Young people in Samoa are better acquainted with the Bible than the average Sunday school scholars in England, and the Samoan's knowledge of the Bible, in very many cases, has changed the heart and lifted the old pagan life to the level of conscious communion with God."



MAP OF SAMOA.

The political troubles which are now causing so much stir in Europe and the United States have arisen from the fact that Germany, whose commercial interests in Samoa are much greater than those of any other nation, has sought to use some internal commotions at the islands for her own advantage. The Samoans, being well supplied with all that they regard as necessaries of life from their prolific soil, were not willing to labor on the plantations of the foreigners. The English and Germans, therefore, have imported laborers from other islands of Polynesia, and this foreign population, not under the authority of the Samoan king, but ruled by the Germans, has been a troublesome element. The old king, Malietoa, was an excellent Christian man, but he was exasperated by the aggressions of the Germans, who openly favored the pretensions of an insurgent chief, Matasese. The English and American authorities did not interpose promptly, as they should have done, to maintain the rightful king. After hiding three weeks in the bush, hoping for British and American support, King Malietoa, in the summer of 1887, gave himself up to the Germans and addressed the following dignified message to his people:



A SAMOAN SAILBOAT.

"To all Samoa: On account of my great love to my country and my great affection to all Samoa, that is the reason that I deliver up my body to the German government. That government may do all they wish to me. The meaning of this is, that I do not desire that again shall the blood of Samoa be spilt for me. But I do not know what is my offense which has caused their anger to arise to me and my country. Farewell. May you be blessed."

The king was taken to the Cameroons, in Africa, and afterward to Germany. The Samoans were helpless, but indignant. As we understand the matter, they have chosen Mataafa as king in place of Malietoa, while the Germans are still upholding the rebel chief, Matasese. The last report encouraged the hope that the German government will repudiate the action of her officials in Samoa, and that her representatives, together with those of Great Britain and the United States, will join in re-establishing and guaranteeing an independent native government. Unless He who rules over all shall overrule the recent events in Samoa in some way beyond human ken, the good work accomplished by the London Missionary Society seems likely to be seriously injured.

THE MICROSCOPICAL INVESTIGATION OF ROCKS.*

By Dr. H. Hensoldt.

Mr. President, Ladies and Gentlemen:

I have often wondered why there are so few in the ever increasing army of microscopists who take an interest in the microscopical investigation of minerals and rocks, and why there are fewer still who have selected this department as their special field of study.

Of course I am aware that this army is mainly composed of amateurs. They do not lack the ability, but in nine cases out of ten they have not the time necessary for thorough and methodical work. Yet among these very amateurs we find a large number of enthusiastic workers, who, in spite of all drawbacks, accomplish wonderful things, make original discoveries, and lead the way to entirely new fields of microscopical research.

Now it may be doubted whether within the whole range of practical microscopy there is a subject which so well repays study, a subject so eminently calculated to afford pleasure and satisfaction to the lover of the microscope, as the investigation of the minute structure of minerals and rocks. It is questionable whether the whole field of zoology and botany, in fact the entire organic division of nature, can present to the inquirer a great complexity of forms, a more wonderful display of colors, a more startling array of problems—problems strange and fascinating in their mystery—than this neglected world of stones.

Here we have a field as yet almost untrodden, and affording endless opportunities for research to an army of workers. We all know what the proboscis of the blow-fly looks like. When we are about to examine it under the microscope, we know exactly what to expect—we have seen it before, and could describe or draw it at any moment. But we do not know what to expect when we come to examine a thin section of granite. We may have seen hundreds of sections of granite before, yet even if we had seen thousands and tens of thousands, this would not warrant us to draw any conclusions as to the appearance of the specimen in question. For the chances are a thousand to one against our having ever seen anything like it.

There are no two granites alike, just as there are no two lavas, basalts, or other igneous rocks alike. The differences in their microscopical structure are perfectly astonishing, especially in specimens of the same kind of rock from different localities. But even different pieces of granite from the same locality may present an almost infinite variety of structural detail. And of twenty sections from one small piece, not larger than a walnut, no two will be found alike. The only kinds of rocks which exhibit a close resemblance, even if taken from different localities, are certain fine-grained sandstones, slates, and other sedimentary formations; and even these, if carefully examined, will be found to show marked differences.

The conclusions which such variations and differences enable us to draw do not affect the life history of some obscure insect or the derivation of a fungus, but involve cosmic problems of universal importance; the history of the crust of our planet, cycles of marvelous changes in the abysmal ages of the past, the disintegration and reformation of the earth's material, and the life of those extraordinary and mysterious bodies, the crystals.

The time is fast approaching when the microscope will be as indispensable to the progressive geologist as it has been already, for a considerable number of years, to the zoologist, the botanist, and the physician. Indeed, even at the present moment, the foremost inquirers in some of the most important departments of geological science depend so much on the aid of the microscope in their researches that they would be almost helpless without it. If that instrument has vastly added to our knowledge of vegetable or animal structure, if it has enlarged our horizon to an immeasurable extent in the domains of the organic world, it is accomplishing at present equally important results in the domain of inorganic nature, for it has completely revolutionized the study of rocks. Some of the facts which have already been demonstrated by the microscopical investigation of rocks border on the marvelous.

A SAMOAN WOMAN.

Minerals may be termed the individuals of the inorganic world. Each has its characteristic features or properties, which distinguish it from every other mineral. Quartz, feldspar, and mica, separately considered, are minerals; but, when occurring in a state of mixture, they constitute a true rock—granite. And it is the determination of these minerals, and of the conditions under which they assumed the forms in which we now find them, which is the chief aim of microscopical petrology.

Thirty years ago, the only optical apparatus employed by geologists for the examination of rock specimens consisted of an ordinary pocket lens, with a magnifying power of from four to fifteen diameters. This was deemed quite sufficient for all ordinary requirements, and some even disdained the use of magnifying glasses altogether. Specimens were only examined externally. It was noted what kind of appearance a freshly broken surface presented; whether the specimens were rough or smooth, coarse grained or the reverse; what kind of odor they emitted when breathed against; how they felt to the touch; whether they yielded to the scratch of a piece of iron or the finger-nail—in fact, the tests which were deemed sufficient in those days appear quite ludicrous in the light of modern achievement.

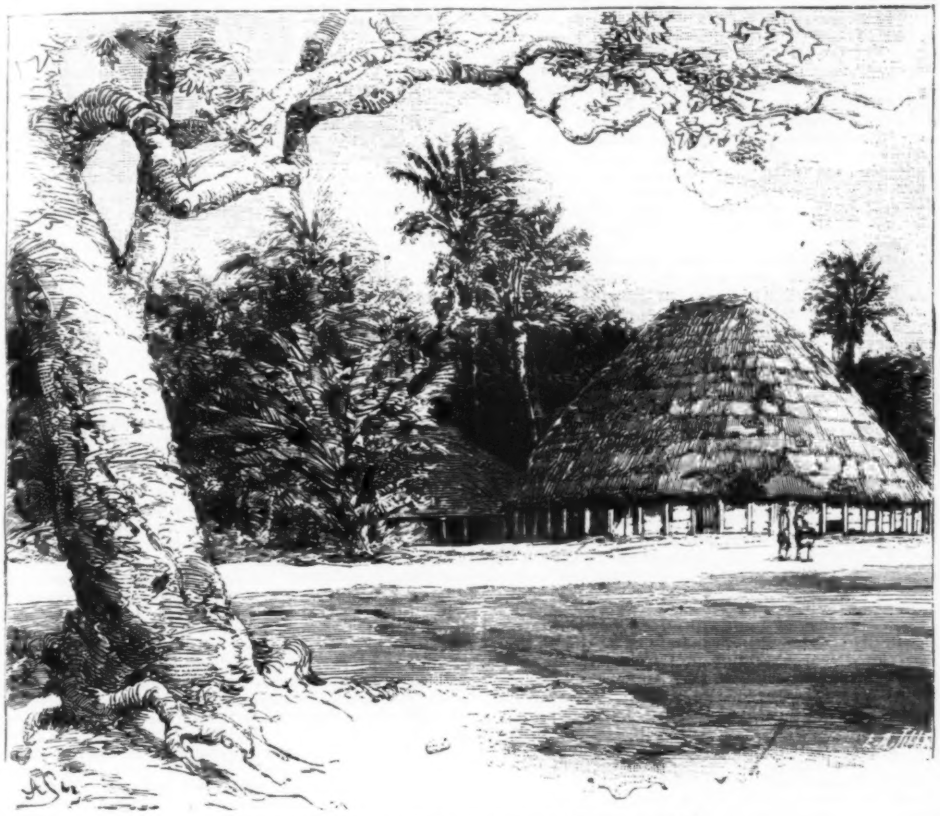
To Prof. Sorby, still living in England, is due, in a great measure, the credit of having first pointed out the fact that a vast deal of information can be obtained from a microscopical investigation of rock specimens. Indeed, he may be called the father of modern petrology. It occurred to him to prepare thin slices of rocks, reducing them by grinding and other processes to a state of extreme thinness, so as to render them more or less transparent. These he mounted in Canada balsam on glass slips, and placed them under his microscope, applying magnifying powers of from 40 to 700 diameters.

The result surpassed his most sanguine expectations. Dull and shapeless stones, some picked up by the roadside, and presenting to the naked eye nothing but a uniform tint of gray, black, or dirty red, transformed themselves under the microscope into fields strewn with beautiful crystals of wondrous colors and forms, or literally blossoming as the rose. Every component mineral could be distinguished by the form, color, etc., of its crystals, and it was found that even the most fine-grained rock was not, as formerly believed, a mix-

* An address before the New York Microscopical Society. Delivered April 20, 1888.

ture of shapeless ingredients, but consisted of minute crystals, sometimes of the most exquisite outlines.

Especially striking and lovely is the appearance of many of the volcanic or igneous rocks when reduced to thin sections and examined under the microscope. The dullish green lava, called pitch stone, which is found in dikes on the Isle of Arran, on the west coast of Scotland, exhibits under the microscope whole forests of fern trees, garlands, leaves, and flowers of marvelous magnificence. A certain granite from Cornwall contains needle-shaped crystals of tourmaline, radiating, star-like, from a common center. Basalts, obsidians, porphyries, serpentines, from various localities show labyrinths of multicolored crystals, resembling rows of



EXTERIOR OF THE COUNCIL HOUSE, SAMOA.

pillars, turreted castles, and fairy caves, glowing in all the tints of the rainbow.

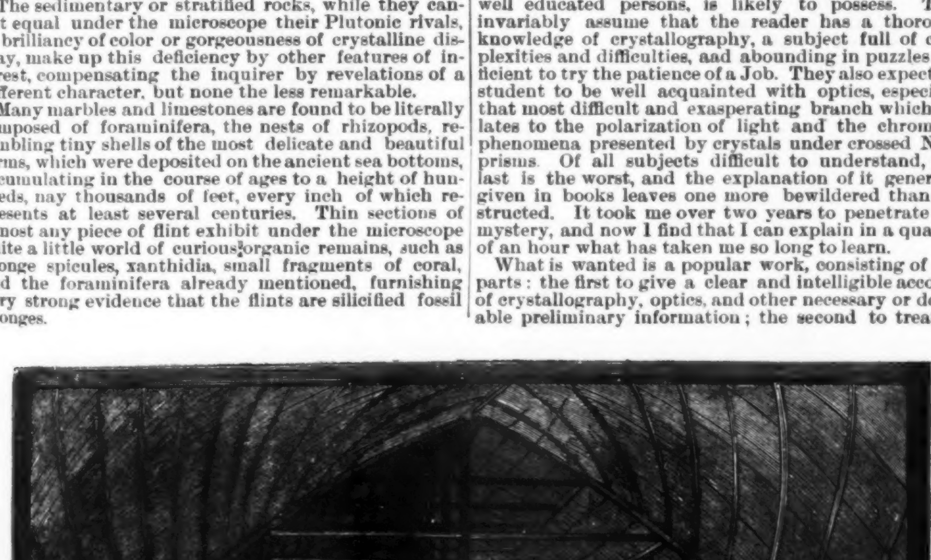
The sedimentary or stratified rocks, while they cannot equal under the microscope their Plutonic rivals, in brilliancy of color or gorgeousness of crystalline display, make up this deficiency by other features of interest, compensating the inquirer by revelations of a different character, but none the less remarkable.

Many marbles and limestones are found to be literally composed of foraminifera, the nests of rhizopods, resembling tiny shells of the most delicate and beautiful forms, which were deposited on the ancient sea bottoms, accumulating in the course of ages to a height of hundreds, nay thousands of feet, every inch of which represents at least several centuries. Thin sections of almost any piece of flint exhibit under the microscope quite a little world of curious organic remains, such as sponge spicules, xanthidia, small fragments of coral, and the foraminifera already mentioned, furnishing very strong evidence that the flints are silicified fossil sponges.

It would be in vain for me to attempt here anything like a detailed description of the discoveries which have resulted from the microscopical examination of rocks. This branch of study, though barely thirty years old, has already contributed such a vast deal of new information to natural science that it has, in more than one respect, revolutionized our old-fashioned conceptions of geological research.

A number of very excellent works have been published by eminent specialists, notably Germans, such as Rosenbusch, Zirkel, and others; but, like most works of the kind, they are too dry and technical to attract or to satisfy the amateur, who wants something explicit and popular to make a study pleasant. These books take too much for granted, and presuppose knowledge which not one in a thousand, of even well educated persons, is likely to possess. They invariably assume that the reader has a thorough knowledge of crystallography, a subject full of complexities and difficulties, aad abounding in puzzles sufficient to try the patience of a Job. They also expect the student to be well acquainted with optics, especially that most difficult and exasperating branch which relates to the polarization of light and the chromatic phenomena presented by crystals under crossed Nicol prisms. Of all subjects difficult to understand, this last is the worst, and the explanation of it generally given in books leaves one more bewildered than instructed. It took me over two years to penetrate the mystery, and now I find that I can explain in a quarter of an hour what has taken me so long to learn.

What is wanted is a popular work, consisting of two parts: the first to give a clear and intelligible account of crystallography, optics, and other necessary or desirable preliminary information; the second to treat of



INTERIOR OF THE COUNCIL HOUSE, SAMOA.

the structure of rocks, the whole to be written in as light and attractive a manner as the subject permits, and to take as little for granted as possible. I am perfectly aware that such a book would necessarily lack in thoroughness and completeness, but to the beginner it would be of incalculable value.

Rutley's work, "The Study of Rocks, an Elementary Text Book of Petrology," contains much useful information, and is a very good book for a beginner; but what it says on crystallography and the phenomena of polarization is altogether too short and fragmentary.

But let those of you who have a mind to enter the field of microscopical petrology, who have a general desire to join the ranks of workers in this very attractive and interesting department, take consolation in this: it is not by any means absolutely necessary to be intimately acquainted with the intricacies presented by the world of crystals or the phenomena of polarization in order to take up this study. If you can master these things, if you can lift the veil of Isis, so much the better for you, so much the greater the enjoyment which you will derive, so much the more will you be enabled to accomplish for science. But you may do a great deal without these things. Many, if not most, of the minerals of which a rock is composed may be determined without a detailed or even general knowledge of crystallography, and it is not always or even generally necessary to resort to the polariscope in order to identify the constituents of a rock. Happily, a number of other features, which are quickly learned and easily remembered, help us in our investigation, and it is almost needless to add that before long even those formidable subjects, crystallography and polarization, lose much of their grim aspect.

You will then be able to determine at a glance the principal rock-forming minerals which you behold in a thin section, and you will then also find that the microscopical investigation of rocks affords you, in the endless variety of forms which it presents, in the gorgeousness of the colors which it reveals, in the wealth of its unsolved problems, a greater, richer, and fuller field for study than any of the old and well beaten paths of animal and vegetable morphology.

Even the general microscopist, the mere onlooker or collector of specimens, might turn with advantage to this subject. It will furnish him with some of the loveliest objects within the whole domain of practical microscopy, and will open up to him one of the most enchanting prospects in the wonderland of science.

THE EARTHQUAKE AT BAN-DAI-SAN, JAPAN.

As it may interest our readers to know the present state of matters at the scene of the great earthquake which occurred lately at Ban-dai-san, Japan, we think it well to publish the following narrative just received by Dr. George Harley, F.R.S., in a private letter from his son, who has recently visited the locality of the sad disaster. The letter is dated December 2, 1888, from on board the Peninsular and Oriental s.s. Verona, while in the Inland Sea on its voyage back from Japan to China.

Mr. Vaughan Harley says that on October 20 last, having procured the services of an interpreter, he started by train from Yokohama to Tokio, where he obtained a permit from the Japanese Foreign Office to visit the Ban-dai-san valley. From Tokio he went by train to Kuragano, where he engaged, for himself and interpreter, a couple of *jinrikshas*, with two coolies for each. On the following morning he started at 4:45 A. M.—that is to say, before daylight. It being then early winter in Japan, the day did not break till 6:45. The weather at the time was both cold and rainy; but so long as the roads were good, the coolies, running tandem fashion, managed to get along at an average rate of from 6 to 7 miles an hour, and accomplished 50 miles a day. On arriving at Inawashiro Lake, after having engaged a guide, he proceeded direct to Ban-dai-san, where the scene that met his eyes, though magnificent, was truly awe-inspiring. It was a veritable valley of devastation. For the whole side of a mountain—three miles in circumference—had been completely blown away, and hurled as if it had been the mere outside wall of a house, into the valley below, completely burying beneath it four villages and their surrounding farms, along with all their inhabitants. Such was the stupendous force of the explosion that the mere wind shock produced by its concussion knocked down, as if they had been nothing more than ninepins, the whole of the trees growing on the opposite mountain side. The river in the valley, too, was so dammed across by the huge mass of detached mountain as to have formed itself into a small lake, the waters of which now occupy the place where formerly well cultivated crops grew.

The catastrophe which brought about these physical changes appears to have been due to the sudden explosion of superheated pent-up steam, either alone or in conjunction with volatile gases, set free by the decomposing chemical action of heat and water on the constituents of the subjacent mineral strata. The whole surrounding ground is at present full of hot springs, giving forth volumes of steam, while from every crack and crevice in the earth issues, either continuously or spasmodically, clouds of hot, watery vapor, so that one has to be very careful where he places his feet. Not only the fact of the presence of these hot springs, but likewise of the still frequent occurrence of earthquakes, shows that the same agent or agents that rent the mountain in twain are still actively at work. Even in the morning of the day following his visit (at 5 A. M.) there was a shock of earthquake, which, although it was strong enough to admit of his feeling the earth quiver beneath him, the people spoke of as being such a mild one as to merit no attention. He says, moreover, that the appearance presented by the standing half of the cleft mountain, with its surrounding clouds of steam, was, to his way of thinking, far grander, and vastly more awe-inspiring, than are either the geysers of Iceland or the yet greater and more numerous ones he had seen in the volcanic district of the Yellowstone Park in North America. For here the scene he witnessed not only plainly pointed to the cause, but gave him ocular demonstration of its stupendous power, and made him feel that, if superheated steam could thus easily, apparently, rend asunder a solid mountain of rock, there could be no difficulty in understanding why the live volcanoes scattered

over the globe were looked upon as safety valves for the effects of the various chemical decompositions brought about by heat and water in the molten minerals within the bowels of the earth. For were there no outlets even to the superheated steam—heated by the vast internal fires up to a point when it possibly resolves itself into its elements—he could readily enough imagine, from what he saw, that its sudden explosion might suffice to shatter the earth's crust into fragments—just, perhaps, as takes place in some of the heavenly bodies, fragments from which ever and anon fall, in the shape of meteorites, upon the surface of our globe. Having got back to the tea house at 7:15 P. M., leg tired and foot sore, but thoroughly satisfied with all he had seen and learned, immediately after a hot bath—a natural one, for there is no need of artificially heating bath water here, nature does that amply for them—and supper, he went to bed, the bedstead being the floor, as is usual in Japan. Next morning, he started on his return journey to Yokohama, and arrived in good time for the sailing of the Verona on the 25th for Hong Kong, where he immediately posted his letter, in order to catch the homeward mail.—*Nature.*

CENSUS OF THE DEFECTIVE CLASSES.

AT the suggestion of Senator Eugene Hale, chairman of the Census Committee of the United States Senate, Professor A. Graham Bell addressed a letter to the committee, in which he refers to some of the results of the census of 1880, especially with reference to the relative increase of the deaf, the blind, the idiotic, and the insane within recent years, as compared with the population in the United States, and to deafness as caused by the marriage of the deaf with the deaf, and makes some suggestions as to the taking of the next census. As this communication is of considerable importance at the present time, when preparations are being made for the next census, we produce it here *in extenso.*

According to the census returns, the defective classes have increased 400 per cent. in thirty years, while the general population of the country has simply doubled. The following table shows the relative figures at each census since 1850:

Years.	Total Population of the United States.	Total Blind Population.	Total Deaf and Dumb Population.	Total Idiotic Population.	Total Insane Population
1850	23,191,876	9,794	9,803	15,787	15,610
1860	31,443,321	12,658	12,821	18,930	24,042
1870	38,558,371	20,320	16,205	24,527	37,432
1880	50,155,783	48,928	33,878	76,895	91,997

I have examined with care the statistics of the tenth census relating to the deaf and dumb, and find internal evidence to show that in their case there has been a real increase greater than the increase of the general population, and not simply an apparent increase due to greater accuracy of enumeration; for, when the whole population of the United States are classified according to their age in 1880, the proportion of deaf mutes among the younger persons is seen to be greater than among the older; indeed, it is proportionally greater as the age is younger, until quite young children are reached.

The following are the number of the deaf and dumb returned in the tenth census:

Period when Deafness Occurred.	Number of Deaf Mutes.
At or before birth	12,155
After birth	10,318
Not stated	11,405
Total	33,878

Classification of these cases according to their age in 1880 shows that there has been an enormous increase of recent years in the numbers of the non-congenitally deaf; but this need hardly be considered as a permanent condition, for it appears to be due to an epidemic of cerebro-spinal meningitis, which will probably die away, as former epidemics have done.

The following table shows the percentage of the whole population of the United States born at each decade, and also the percentage of the congenitally deaf population:

Period of Birth.	Total Population Living in 1880.	Congenital Deaf Mutes Living in 1880.	Percentage of the Whole Population Living in 1880.	Percentage of Congenitally Deaf Population Living in 1880.
Before 1780	4,016	....	0·0080	....
1781–90	20,863	9	0·0416	0·074
1791–1800	196,197	63	0·3912	0·518
1801–10	776,507	241	1·5482	1·983
1811–20	1,330,095	472	2·6488	3·883
1821–30	3,111,317	751	6·2033	6·179
1831–40	4,558 256	1,078	9·0882	8·870
1841–50	6,369,362	3,614	12·6992	13·280
1851–60	9,168,393	2,460	18·2798	20·240
1861–70	10,726,601	3,398	21·3866	27·958
1871–80	13,394,176	2,068	26·7051	17·015
Total	50,155,783	12,154	100·0000	100 000

The indications are that the congenital deaf mutes of the country are increasing at a greater rate than the general population.

The great and sudden decrease in the numbers of deaf children born in the last decade (1871–80) is probably due to imperfect returns of deaf mutes under ten years of age; for, though 54 per cent. of all the deaf and dumb were deaf from birth, only 30 deaf infants were reported in the census of 1880, and only 49 between the ages of one and two, out of a total deaf mute population of 33,878.

Statistics in my possession show that in the year 1819 deaf mutes began to marry partners who were themselves deaf and dumb.

The percentage of intermarriages has continuously increased, until now not less than 90 per cent. of all deaf mutes who marry, marry partners who are themselves deaf and dumb.

The latest statistics collected by me include 1,443 cases of marriage. Of these 1,443 deaf mutes, I find that 71 (or 5 per cent.) had married hearing persons, and 1,372 (or 95 per cent.) had intermarried among themselves.

In 1828 a deaf mute child was born of a deaf mute father and mother, and now such cases can be numbered by the hundred. My statistics are based upon a list of 528 deaf mutes, mostly young, who have one or both parents deaf.

Some of these children have already married deaf husbands or wives, and deaf offspring have appeared in the third generation.

I can cite families in which the deafness has been handed down through four generations, and can give in minute detail particulars relating to a family in Maine in which congenital deaf mutes have appeared for five successive generations in increasing numbers, and in which the younger deaf mutes are marrying deaf mutes.

My list of deaf children of deaf parents (all, excepting one, born before 1880) comprises 528 cases (mostly young), 91·6 of whom were deaf from birth.

Upon the assumption that 528 such cases were living when the tenth census was taken, we obtain the following results: 1. One person in every 1,480 of the general population was deaf and dumb, and one person in every 64 of the deaf mute population was a child of deaf mute parents. 2. One person in every 2,736 of the general population was deaf from birth, and one person in every 38 of the congenitally deaf population was a child of deaf mute parents.

The laws of heredity indicate that, if these deaf children should marry congenitally deaf husbands or wives, an increased proportion of deaf offspring will appear in the next generation; and that the continuous intermarriage of congenital deaf mutes from generation to generation may ultimately result in the formation of a deaf variety of the human race in America, in which all or most of the children will be born deaf.

In these conclusions I am supported by the following American men of science, all members of the National Academy of Sciences, and most of these experts on the subject of heredity. These gentlemen are Professor Edward D. Cope, editor of the *American Naturalist;* Professor Alpheus Hyatt, of Harvard University; Professor William H. Brewer, of Yale University; Dr. Bowditch, of Harvard University; Professor Simon Newcomb, of Washington, D. C.; and Professor W. K. Brooks, of Johns Hopkins University.

I would, therefore, urge upon the United States the importance of examining in the next census the marital relations of defective persons, and the extent to which their defects have been inherited by their offspring.

The enumeration of the defective classes is always found to be itself defective.

However perfect the classification may be, the returns of these classes will always be incomplete, on account of a natural objection to expose the defects of relatives, especially when these are very young.

Accuracy of enumeration will be promoted by eliminating from the census schedules (as far as may be possible) every question that could wound the feelings of parents or friends of afflicted persons. For example, if the enumerator approached the subject of defects by asking whether the persons enumerated were perfect in sight, hearing, mind, and body, he would be more likely to secure the information desired than if he asked a fond mother whether her child was "blind, deaf and dumb, idiotic, insane, maimed, crippled, bedridden, or otherwise disabled."

There are degrees in every defect, and the lesser forms are more capable of amelioration than the graver. Classification under the graver forms tends to the exclusion of the lesser from the returns, but classification under the lesser forms would include the graver, and be less objectionable to friends, so that evasions would be fewer, and the returns more accurate and complete. For example, the blind, deaf and dumb, idiotic, insane, maimed, crippled, bedridden, and otherwise disabled would all be returned under the head of defects in sight, hearing, mind, or body, but the converse would not necessarily be true.

The returns should include all persons laboring under disabilities of sight, hearing, mind, or body, of sufficient magnitude to prevent education in ordinary schools, lessen wealth-producing power, and incapacitate for military service.

The deaf and the blind should be grouped into a sub-class by themselves, and separated as much as possible from the other defective classes, because they are enumerated chiefly for educational purposes, whereas the others need eleemosynary care or restraint.

Public establishments for purely educational purposes should be classified as "schools," and not as "asylums." They should be included in statistics relating to the general education of the people, and excluded from those relating to charitable institutions.

Many children who cannot profitably attend ordinary public schools on account of disabilities are allowed to grow up without instruction, because parents object to send them to asylums, or institutions governed by State boards of charity.

The statistics of the tenth census show the following figures relating to defective children of school age (six years and under twenty-one):

	Total in the United States.	Total in Special Schools.
Blind	7,768	1,534
Deaf and dumb	15,059	4,893
Idiotic	29,373	1,942
Insane	3,184	....

The term "deaf and dumb" is not only objectionable in itself, but is incorrect, because it classifies those who belong to this class as laboring under a double disability instead of a single one.

Deaf mutes are simply persons who are deaf from childhood, and dumbness or muteness is the result of the natural defect, and not a defect in itself. The vocal organs are not defective.

Many of the so-called deaf and dumb can speak. Some had acquired the art before hearing was lost, and others acquired it by instruction in school.

In the census of 1880 all persons who lost hearing before they reached the age of sixteen years are classified as "deaf and dumb," whether they can speak or not.

This incorrect and very objectionable classification leads to evasion and inaccurate returns.

Dumbness by itself is not a defect calling for enumeration in the census (unless, indeed, for statistical purposes and the determination of causes), for defective speech alone is not a disability that prevents instruction in ordinary schools. It does not materially lessen wealth-producing power, nor does it incapacitate the person for military service.

Persons who have not studied the subject generally fail to realize that deaf mutes should be classified among the deaf, and not among the dumb, and enumerators, therefore, can hardly be expected to follow the classification.

For the sake of accuracy in the returns, therefore, it would be well to make defective speech a subject of inquiry in the primary schedule relating to population. The dumb who are deaf and the dumb who are idiotic will appear on supplementary schedules relating to the deaf or the feeble minded, and the dumb who are neither deficient in mind nor hearing need have no special schedule of inquiry.

Special schedules relating to all the defective classes (except the dumb) should be prepared with the assistance of experts of two kinds, viz., specialists who have studied the causes of the defects and teachers who are familiar with the special methods of instruction necessary.

The gravity of the disabilities resulting from deafness can be ascertained from two elements: (1) the age or period of life at which the defect occurred; and (2) the amount of deafness (whether total or partial). The former element is the more important of the two, for a slight defect of hearing in an infant results in graver disabilities than total deafness occurring in adult life. For example, in the case of the deaf infant, the defect interferes with the acquisition of language through the ear, and the child remains dumb. His thoughts are carried on without words, so that a mental condition exists which is abnormal. His ignorance is so great as to be appalling, for his mind is deprived of everything that other people have ever heard of or read about that is not derived directly from their own observation. Without special instruction, such children grow to adult life with all the passions of men and women, but without the restraining influences that spring from a cultivated understanding.

Persons who become deaf in adult life have no greater disability than the defect itself; but, where deafness occurs in childhood, incidental disabilities arise which are greater than the natural defect, but because they are incidental, and not natural, they are capable of amelioration, and even complete removal, by suitable instruction in special schools. Hence the very great importance of a correct enumeration of the young deaf children.

In the primary schedule relating to population, the defective classes should be grouped together under the head of "physical and mental condition," instead of under "health," as was done in 1880. The following form is suggested for incorporation in the primary schedule relating to population:

PHYSICAL AND MENTAL CONDITION.

	Condition of						
	The Senses.			The Mind.		The Body.	
Is the person [on the day of the enumerator's visit] sick or temporarily disabled, so as to be unable to attend to ordinary business or duties? If so, what is the sickness or disability?	Sight.	Hearing.	Speech { of persons five or more years of age.	Mental Development.	Mental Health.	Bodily Condition.	Bodily Health.

The enumerator should be instructed to ask whether the person has perfectly normal sight, hearing, and speech; whether the mind is normally developed and in a healthy condition; and whether the bodily condition is normal and the general health good. If the answer is "yes," the enumerator should indicate the reply by a horizontal mark (—) placed in the proper column; if "no," by a mark sloping from right to left (/); and, if the question is not answered in a satisfactory and reliable manner, the column should be left blank. If the physical or mental condition is reported as "not perfectly normal" (/), the enumerator should then inquire whether the disability is sufficiently great to prevent instruction in an ordinary school, to interfere with the acquisition of a suitable means of livelihood, and to incapacitate for military service. If the answer is "yes," he should change the negative mark (/) into a cross (×), and proceed to put the interrogatories contained in the supplementary schedule relating to the special class of defect noted.

As the supplementary schedules should be prepared with the assistance of specialists, it may perhaps not be advisable for me at the present time to refer to the details, excepting so far as to say that inquiries should be instituted relating to the causes of defects and their inheritance by offspring. The marital relations of defective persons should be noted and the results tabulated. The total number of children born to them should be recorded, and the number who died young. The record should also note the number of defective and normal offspring.

In examining the ancestry of deaf mutes, I have had occasion to consult the original population schedules of

former censuses, which are preserved in the Department of the Interior; and I have found little difficulty in tracing the families backward from census to census in the male line of ascent. If the name of the father had been given in former censuses, it might now be possible for genealogical experts to trace from these records the American ancestry of every person now living in the United States in every branch, for the name of the father would give the maiden name of females. I therefore suggest that in the census of 1890 the father's name should be noted in that part of the schedule that relates to the nativity of the parents, so that the people of the United States may leave to their descendants genealogical records from which their full ancestry may at any future time be ascertained.

THE GOLDEN-FRONTED WOODPECKER.

(*Melanerpes aurifrons.*)

By E. M. HASBROUCK.

EASTLAND COUNTY, Texas, is situated between latitudes 32°-33° and longitudes 98°-99°, or a little northeast of the geographical center, and is wide famed as the poorest and most unattractive portion of the State. Located as it is on the edge of what are known as the cross timbers, it combines both wooded country and small inroads of prairie, and is composed largely of sand ruffs and limestone formation. The elevation varies from twelve to fourteen hundred feet, and while maps of the country show plentiful irrigation, water is in reality more of a luxury than a staple article. As a consequence, it offers neither an inviting aspect to the traveler nor over-inducive prospects to the settler, and while some few people have settled to a certain extent throughout the country, one may frequently travel an entire day without seeing more than one or two cabins.

It is a poor country indeed that cannot furnish something of interest to the naturalist, and central Texas is certainly no exception to the rule.

I was engaged in running a line from north to south near the western boundary of the country, and being overtaken by one of those abominably bad spells of weather termed "wet northers," had pitched camp in a grove of live oaks on a slight bluff overlooking Deadhorse Creek. The tents being raised, mules staked out, and everything gotten in readiness for a siege, the next thing in order was to investigate the bird life of the locality. Time was short, as the storm was rapidly advancing across the heavens, heralded by light wavy clouds nearly white in color, followed by heavier irregularly shaped masses of vapor, and these in turn by the almost black cumulus storm clouds just showing themselves above the tree tops. Giving my little Stevens collecting gun to Wright, my teamster, who frequently assisted me in bird matters, with instructions what to shoot, I took an opposite direction with my heavy tenbore in search of yellow-headed blackbirds in an adjoining clearing.

The storm, thanks to fortune, was longer in coming up than usual, and it was some two hours later that I finally wended my way back to camp, having among my birds a Harris sparrow (*Zonotrichia querula*), a bird new to me, and although wet through (the storm had by this time begun), my feelings were in the seventh heaven of happiness. Wright's first words were: "Mr. Hasbrouck, I've shot a yaller-headed peckerwood." "Have you?" replied I. "Let me see it." (For as yet the possibility of finding *M. aurifrons* had never entered my head.) He brought it, and awaited my reply.

When one has started out with a particular aim in view, searched long and diligently for that which is desired, and has met with repeated failures and discouragements, and at length, utterly disheartened, is ready to abandon everything, what feelings of emotion thrill him as he at length holds within his grasp that for which he has so long striven in vain; what rare joy throbs every pulse as he looks on that which until now has ever been beyond his reach, and for which he would have given his very all to possess!

It was with some such feelings that I stood silent for awhile, gazing on the first specimen of the golden-fronted woodpecker I had ever seen—beautiful I had had no doubt it was, but it had never occurred to me that nature could be so extremely tasty in the arrangement of her colors. The wood duck is handsome, but too gaudy; the nonpareil is gorgeous certainly in his mantle of green, yellow, blue, and red, but his colors are thrown together without that harmony of contrast so much admired; while the Baltimore oriole and scarlet tanager, although harmoniously dressed, still lack a certain something to set off as it were their otherwise faultless attire.

It was a female I held, although I did not know it at the time, and subsequently, on making the discovery, my speculations and final decision as to the appearance of the male shot very wide of the mark when I came to possess one. I asked my driver the particulars of the capture, and on learning that he had seen several others, was more than anxious that the norther should continue another day. Fortune in this respect favored me, but as bad luck would have it, a severe cold caught in the previous day's wetting prevented my going out, and I had to rely upon what Wright could secure. In the course of the day he brought me three more—two males and one female; and if I was charmed with the latter on the previous day, the former certainly held me entranced, and the fact that my illness prevented me from stirring around the following day but increased my chagrin on being amid rare and, to me, new birds without being able to observe them for myself. I gathered from Wright all that was possible concerning them, fully determined to be able to recognize them should I ever meet them again, and on the next morning struck camp and proceeded with my duties. Just as we were leaving, the note of a strange bird sounded on my ears and with it came the information: "That's a yaller-headed peckerwood." I carried that sound in my head for days, but it was not until four weeks had passed by, and I had entered the same section of the country, that I finally had the pleasure of knowing and taking the bird myself. I am aware that the habits of the *Picidæ* are very much alike in general, still there are some points in which this species differs from any that has come under my observation, and with them a short account of the bird may not come amiss. In the first place, the golden-fronted woodpecker is a bird of strictly local occurrence. Unlike his near relative, the red-bellied woodpecker (*Melanerpes carolinus*), which is found in swamps and on upland ridges, in the densest part of the forest and equally as common in the clearings, certain sections of the country have decidedly more attractions for him than others, and the boundaries of these, once established, are, to all appearances, studiously observed. In the single portion of Eastland County in which they occur they may be said to be fairly abundant, but outside of an area of twenty-five square miles, I have searched for them in vain. True, I took one early one morning on the banks of the South Leon River, five miles from the accustomed limits; but then are there not exceptions to all rules?

This tract of country extends from the Circo and Brownwood road on the east, beginning at a place known as Merrill's (ten miles south of Circo), in a northeasterly direction to the Carbon and Rising Star road, a distance of about five miles, thence south toward Rising Star, following the road with comparative closeness for about four miles, then back to Merrill's, forming an irregularly shaped triangular section of country. This may at first appear absurd; but when I state that I have surveyed entirely around it and through it in several directions, and further add that I once spent nearly an entire afternoon on one side of a hill without success, and on crossing a distance of perhaps a quarter of a mile was almost at once in the land of plenty, it must be admitted that there are grounds for the above statements. That the country presents certain peculiar characteristics is true, for the timber is entirely oak, of a species known as post oak, and the ground more or less thickly covered with a short, scrubby growth known as "shin oak" or "shinnery." This particular post oak region differs from the surrounding country merely in that the *tops* of the trees are nearly all dead (the whole country is post oak, *Quercus obtusilata*, live oak, *Q. virens*, black jack, *Q. nigra*, and shinnery), and this

MELANERPES AURIFRONS.

is what apparently suits our bird. Perched on the topmost sway of some leafless branch, he will sit for many minutes silent and motionless, then, with a loud rattle, bounds through the air to join a comrade on a neighboring tree, or to seek a meal in some decaying branch or knot hole. This habit of perching motionless is of itself enough to identify it among others; and while both *carolinus* and *aurifrons* will frequently be found in the same tree, it is a matter of a moment only to separate as it were the two species. Moreover, the latter has an appreciably larger bill, and suffering, as he does, a moderately close approach, this can be readily seen.

Their note is peculiar, combining the "chup, chup," of *carolinus* with a certain shrillness and accent of their own, while the call note, either flying or at rest, is similar to that of the red-headed woodpecker (*M. erythrocephalus*), and at the same time not unlike that of the golden-winged woodpecker (*Colaptes auratus*). These notes once learned are readily recognized, still I can vouch that it takes not a little practice to distinguish between a red head in one tree and the golden front in the next, or between a golden front and a *carolinus* where both are on the opposite side of a ravine and hidden from view, and I have more than once shot the latter even when morally certain it was what I wanted. From this it will be seen that they resemble largely the red-bellied woodpecker; differing from them in that, where they are red, the former is of an elegant gold color, and the head of the male, instead of one solid color above, as in *carolinus*, is divided into three; first of which is the ashy gray or ground color spread over the entire under parts, with the exception of the golden median line; the nape is of a gorgeous old gold tinged strongly with red and the crown surmounted by a patch of crimson; while the nasal tufts are of the hue from which the bird derives its name. The female differs from her mate in size, being smaller, and lacks the crimson crown patch; in other respects they resemble their near relative. It must not be omitted to state that there is a marked difference in size between the two species, the female of the one under discussion being as large and frequently larger than the male of the other, while the male is proportionately of greater size.

The habitat as given is "valley of the lower Rio Grande, southern Texas and eastern Mexico," and mine I think is the most northern record yet published. As regards the breeding habits, I am unfortunately not posted; farmers tell me that they nest the same as the others (meaning *carolinus*), and a hole occupied the previous season in a door yard was not to all appearances to be distinguished. This same farmer complained that they made themselves nuisances by sucking the eggs of his poultry, and that he had caught them in the act on more than one occasion. I have no reason to doubt the old man's veracity, but I do doubt that any of the present family are given to despoiling the eggs of other birds.

COCA.

A VALUABLE article has recently appeared in the *Kew Bulletin* on the history of coca, a remarkable plant, which has received so much attention of late years. The anæsthetic qualities of cocaine, one of the alkaloids contained in it, are well known, as are also coca wine and other preparations of its leaves. Three hundred years ago, a Spanish traveler botanist wrote a description of the properties which it possessed, and the uses to which it was put by the South American Indians. It appears that the Indians chewed a paste which was made from the leaves, for the purpose of removing hunger and thirst and for instilling sufficient nervous and bodily vigor into the system to enable them to undergo an extraordinary amount of fatigue. At the present time the plant is extensively cultivated in the Andes of the Argentine Republic, Bolivia, Peru, Ecuador, and New Grenada, the head center being at La Paz, in Bolivia, and almost the whole of the produce is consumed in South America.

It succeeds best in the mild, but very moist, climate of the lower mountains, at an elevation between 2,000 feet and 5,000 feet above the level of the sea, and the care and cultivation which are necessary for the growth of tea and coffee are required. It is a leaf crop, and in favorable localities two or three crops may be gathered in the year; but, differing from tea, the largest and most matured leaves are sought, as they contain most of the alkaloids which render them a marketable product. The leaves, when unbroken, are of a fine green color, and possess a delicate, agreeable, and somewhat aromatic odor, which has been compared to the combined odor of hay and chocolate. Since the discovery of its anæsthetic properties, the demand for export in South America has increased; but it has been noticed that during transit to this country there is a distinct loss in the alkaloids generally, as well as in cocaine, and consequently it has become the practice to extract the alkaloids from the leaves in South America, and export a crude preparation, which is largely taken up by manufacturers of cocaine.

FIGUE.

SCIENTIFIC agriculture, according to a recently issued consular report, is almost unknown in Colombia. The country has an area of 520,000 square miles, a population of 3,000,000 only, and embraces a great variety of climate and soil. At present there is only one steam thrashing machine in the country and about fifteen worked by mule power, most of them manufactured by Wallis & Stevens, Basingstoke. The foreign plows in use are also most of them English, made by J. & F. Howard and Ransome, Sims & Jefferies. But lately American wooden plows have found a readier sale, on account of smaller cost of their transport. The plow in general use is a most antiquated and defective machine, which just scratches the ground to a depth of five or six inches, without turning it over. The ground requires to be carefully hoed after the use of these plows, and even so remains in a very insufficiently prepared condition.

The American aloe (*Agave Americana*), called "figue" in this country, though a wild rather than a cultivated plant, is of great importance on account of the numerous purposes for which its fiber is used. It grows wild in all climates and soils from the sea level to 10,000 feet. Most of the hedges are formed of it in many parts of the country, and it is planted here and there on waste patches of land in the districts where the industry of extracting the fiber is chiefly carried on, but the wild plants are nearly sufficient for the demand. The leaves are picked off one by one when they have arrived at the proper age, but generally not till after the plant has produced its flower stem; soon after that the plant dies, and is replaced by another grown from a shoot. The mode of extracting the fiber is very slow and laborious. The leaves are soaked in water and then beaten with sticks or mallets on a board or smooth stone, and the fiber picked out by hand with the aid of a knife. A skilled and practiced laborer can only produce some 10 lb. of fiber a day by this method. A simple, easily worked, and, above all, a cheap machine, not too heavy to be carried over mountain roads, in pieces at least, would be of great service, and would largely increase the production. The number of plants now grown is limited by the capacity of the people to extract the fiber; any quantity could be planted without cost or labor; and if such a machine were introduced as they could afford to buy and easily learn to use, the prices of all articles made of the fiber could be considerably reduced. The chief uses of figue fiber in Colombia are in the manufacture of the "alpargates," or sandals, used in place of boots, shoes, and stockings by a large proportion of the poorer classes—perhaps one-half of the people—for sacks, for ropes, girths, pack saddles, and other mule furniture, which is a large item in a country where all transport is by mule-back, and for numerous other purposes. I have seen such widely different estimates of the value of the articles manufactured, ranging from $10,000,000 to $30,000,000 yearly, that it is impossible to form an accurate opinion on the subject; but taking the lowest figures, which are probably nearer to the truth, the industry would still be one of the most important in Colombia. No other part of the plant than the fiber is used; the Mexican drink "pulque," made from the same plant, is unknown here. The fiber of a species of *Furcræa*, called "pita" in this country, is also used. It is finer and stronger than that of the figue, and is used chiefly for nets, hammocks, and other articles requiring great strength. Its production is very limited.

JANDIN'S HYDRO-PNEUMATIC DREDGER.

At Anse, in the Saone, some experiments have just been made with a dredger of a new system combined with a forcing and conveying apparatus carried upon a raft 1,000 feet in length. This dredger, which was devised by Mr. Jandin, an engineer of Lyons, and constructed for the port of Uleaborg, Finland, is designed for excavating a canal 20 ft. in depth from the city of Uleaborg to the Gulf of Bothnia, in the mouth of the river Ulea, where the depth of water has been reduced to about 13 ft. by accumulations of sand.

Figs. 1 and 2 represent the temporary installation of the machines upon a canal boat, and the conveyor established upon a raft for a length of 39 ft., and upon land for the rest of the length of 1,000 ft.

The apparatus consists of a hydro-pneumatic dredging pipe, which raises the mixture of water and excavated material and empties it into a large cylindrical reservoir which constitutes the forcing apparatus. The dredging pipe, the orifice of which rests constantly upon the bottom, forms the axis of a rigid frame which is guided vertically by the sides of a well at the extremity of the boat. Its upper part is connected with a horizontal pipe which enters the reservoir through a flexible elbow. Near the lower orifice of the dredging pipe there is arranged an annular injector, which introduces compressed air upwardly into the pipe. This injection of air produces a suction, while, at the same time, it forms in the pipe a mixture of air, water, and material carried along by the water—a mixture whose density is less than that of the water. It is easily conceived that, with a given depth of water, it is possible, with the coefficients furnished by experiment, to calculate the volume of air necessary to make the external charge upon the orifice greater than the weight of the column of the mixture ascending above the level of the water to a fixed height.

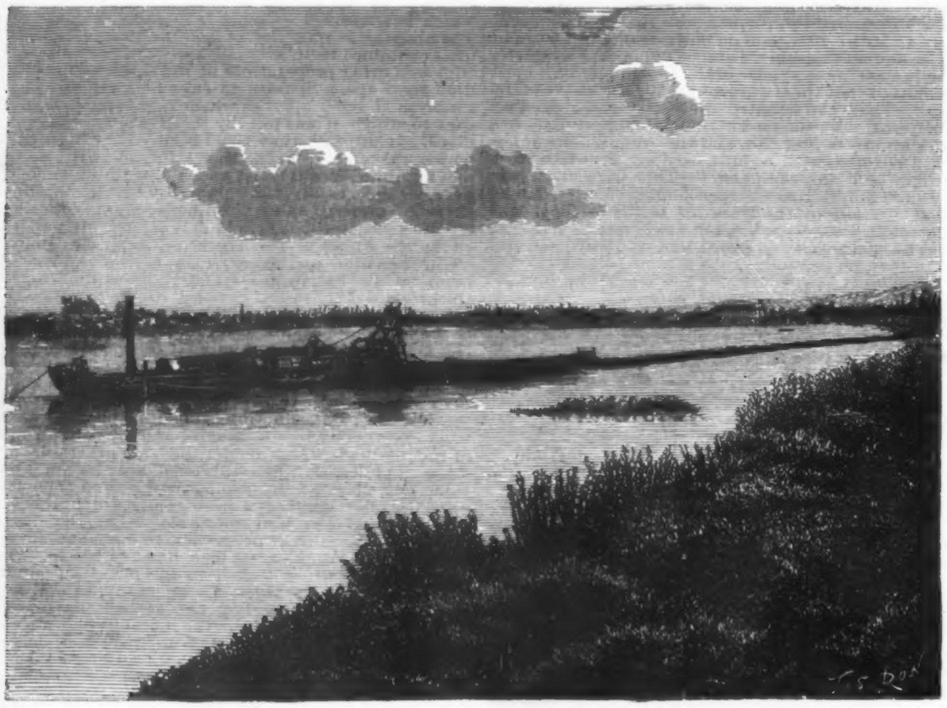


Fig. 1.—HYDRO-PNEUMATIC DREDGER, WITH CONVEYOR.

The principal advantage of this system is that there is no obstruction possible, as the orifice presents a passage that is smaller than the constant section of the pipe, and no parts in motion are in contact with the excavated material. In this way there are avoided two of the inconveniences of pumps applied to dredging, and which cause frequent stoppages and necessitate costly repairs.

Jets of compressed air, arranged around the orifice and directed against the earth, disintegrate the latter, and increase the proportion of the material carried along by the velocity of the water—a proportion which, in ordinary depths of 20 or 25 ft., reaches, as regards sand, 25 per cent. of the volume of water.

In the first trials of the apparatus, made below the Saint Rambert dam, upon a bottom formed by very large pebbles, we saw stones of from 25 to 35 pounds dredged from depths of from 13 to 16 ft. The power of suction is remarkable. At the spot where work is being carried on upon the pneumatic foundations of the Morand bridge upon the Rhone, where a dredger of this system is employed, it dredged in 38 ft. of water a bundle of chains 1¼ in. in diameter and weighing 110 pounds, the height it was raised above water being about 10 ft. This apparatus, which is 10 in. in diameter, is actuated by a compressor, which takes in 6,100 cubic inches of air per second and is situated at 150 yards from the pier where the dredging is going on.

The forcing apparatus, which is a cylindrical reservoir ten feet in diameter and twenty-two in length, with convex ends, and having a capacity of 176 cubic feet, receives the mixture of water and material. The air escapes through an opening above surmounted by an open dome, upon the side of which there is a waste pipe. When the reservoir is full and the water is making its escape through the waste pipe, a single external lever, maneuvered by the chief dredgeman, closes valves that in turn close internally the orifice of the dredging pipe, and open the air port, and at the same time reverse, through three-way cocks, a current of compressed air, which is then forced through distinct pipes into the reservoir and led to injection tubes properly spaced in the lower part of the reservoir. The effect of the jets of compressed air, formed under the mass of earth and water, is to lift the material while mixing it with water and throwing it, as if by successive shovelfuls, toward the orifice situated at the lowest point of the excavation.

The air traverses the mass of water and material (the bubbling of which, rendered very noisy by the clashing of stones against the sides, is heard externally) and flows to the upper part of the reservoir, where is established the pressure corresponding to the distance and height to which the material is forced.

The total time taken to force to a distance of 1,000 feet is six minutes, two of which are consumed in the passage through the conduit. The end of the tubing is worked by the escape, at the end of the conduit, of a wheat-sheaf jet of water and air projected through an explosion to 48 feet from the orifice, the conduit remaining empty and being cleaned out by this final action of the air. At the same time, the automatic valve that closes the upper orifice of the reservoir opens by its own weight. The lever that works the cocks is then reversed, and the air is sent to the dredging pipe, and another filling at once occurs.

Thus the dredging and forcing occur successively by periods of from 5 to 6 minutes, the boat remaining immovable during the forcing period.

In the trials on the shore, the shifting of the boat was easily effected by hand windlasses, but the new 104 foot iron boat carries upon its deck four windlasses actuated by a vertical steam engine.

As may be seen, this system is specially adapted to the forcing of the dredged material to a great distance, or to elevating it upon the bank to considerable heights, for the pressure at the beginning of the conduit may easily reach three atmospheres, which would effect an elevation to ninety-five feet—a height that exceeds the ordinary conditions.

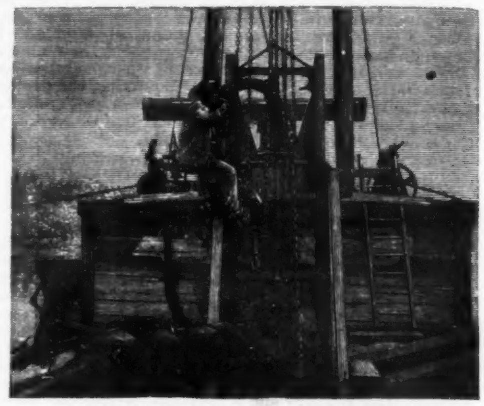


Fig. 3.—JUNCTION OF THE CONVEYOR WITH THE FORCING APPARATUS.

When the material is to be forced to a short distance (as will be the case at Uleaborg for a certain length of the canal), as it can be emptied behind a jetty, the system may be so arranged that the dredging and forcing may be effected continuously and simultaneously. The dredging pipe (Fig. 3) is then prolonged directly by the floating conveyor, to which it is attached by a flexible metallic elbow.

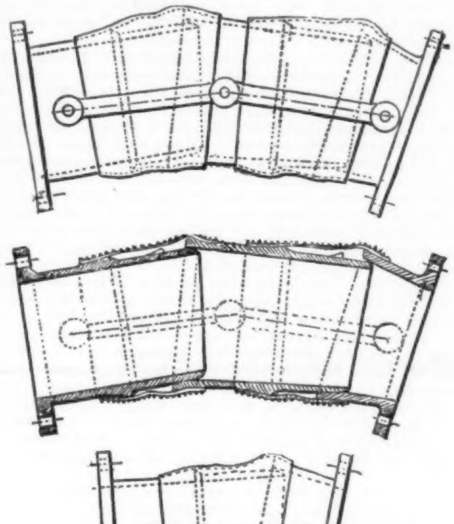
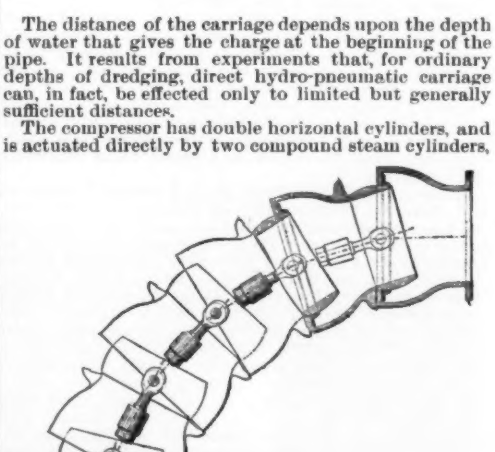


Fig. 4.—DETAILS OF THE JANDIN JOINTED CONDUIT.

The distance of the carriage depends upon the depth of water that gives the charge at the beginning of the pipe. It results from experiments that, for ordinary depths of dredging, direct hydro-pneumatic carriage can, in fact, be effected only to limited but generally sufficient distances.

The compressor has double horizontal cylinders, and is actuated directly by two compound steam cylinders,



Figs. 5 and 6.—DETAILS OF THE BONY JOINTED CONDUIT.

with variable expansion by hand in the small cylinder and fixed introduction in the large one, with condenser. The advantage of this arrangement is that, since the expansion is effected successively in the two steam

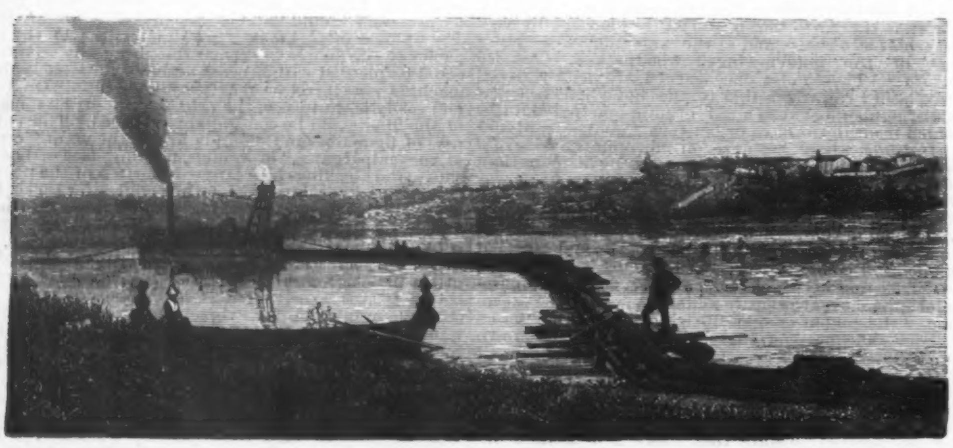


Fig. 2.—HYDRO-PNEUMATIC DREDGER, WITH CONVEYOR.

cylinders, the stress upon the pistons varies within quite narrow limits. This better responds to the conditions of the work of compression, as the maximum stress is produced in the compressing cylinders during the period of forcing the excavated material.

The carrier or conveyor consists of two iron plate pipes with Jandin joints of steel rings and rubber washers, secured with conical pins. Here and there are arranged flexible joints, which are likewise employed for the jointing of the dredge pipe and the connecting of the floating conveyor with the forcing apparatus carried by the boat (Figs. 2 and 3). This new system seems to offer a fit solution of the question of the joints necessary for movable conduits for the carriage of excavated material.

One of the first systems patented by Mr. Jandin consists (Fig. 4) of short cast or plate iron cylinders set into one another at angles varying up to 15°. These cylinders are connected by external stiff, jointed rods that resist the accidental extension or compression of the pipes.

The joints of the cylinders are rendered tight by slipping a flexible rubber collar over them. The two extremities of the collar are strongly secured, and the collar is spirally wound with a strip of canvas in order to resist the internal pressure. As the junction axes are very near the point of contact, the internal pressures are almost completely balanced with respect to them, so that the connecting rods are capable of operating under pressure with a very feeble stress, tending to straighten out the system of joints. The figure shows the arrangement of the latter as employed on the hydro-pneumatic dredger of the port of Manilla. They are eight inches in diameter.

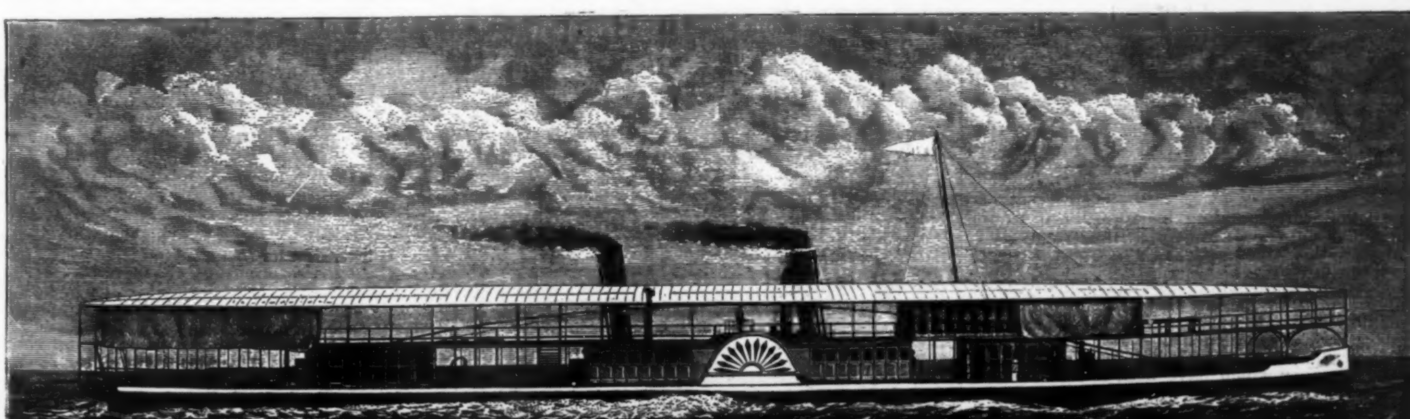
Another system, due to Mr. P. Bony, has been adopted for the Uleaborg dredger, and is a notable improvement upon the preceding. It is shown in Figs. 5 and 6. Here the external junction axes pass through the center of a sphere, one of the zones of which forms the surface of contact with a feeble play between the two elements. There results from this a complete equilibrium of the internal pressures with respect to the axis. The joints are made tight by leather applied to the spherical part, which is turned and is protected from contact with the excavated material by a metallic guard in contact with a small circle of the sphere.

The connecting pieces of the two elements are set into one of the latter and jointed with the axis carried by the other. It results from this that the difference of the internal and external pressures upon the spherical part in the plane of the curvature are distributed by these rigid pieces over the external pivots, and thus oppose but a slight resistance to rotation.—*Abstract from Le Genie Civil.*

THE LIGHT DRAUGHT STEAMER BURMA.

WE give an engraving of the Burma, a steel paddle steamer, a very good model of which was exhibited at the Glasgow exhibition. She was built by Messrs. R. Duncan & Co., of Port Glasgow, and engined by Messrs. Rankin & Blackmore, of Greenock. This vessel was constructed to the order of the Irrawaddy Flotilla Co., limited, of Rangoon; and being built for river service is of very light scantling, so as to insure shallow draught. The following are the registered dimensions: Length, 249·9 ft.; breadth, 30·1 ft.; depth of hold, 8·85 ft. The tonnage is 476·31 tons gross, and 345·37 net register. There is a light awning deck supported by stanchions, above which there is a galvanized sheet iron roof. To strengthen the light, shallow hull there are two longitudinal girders under deck, running to within 37 ft. of the stem and 32 ft. of the stern. These girders stand 2 ft. above the deck at amidships, and are gradually curved downward toward the ends, finishing at a height of 6 in. above the top of the floors. The vessel is fitted with accommodation galleys, etc., for Europeans and natives. The engines, which, as stated, are by Rankin & Blackmore, are of the compound, jet-condensing, direct-acting, diagonal type of paddle-wheel engines.

The cylinders are 34 in. and 57 in. and the stroke is 54 in. The paddles have feathering floats. Steam is supplied by two steel boilers 9 ft. 8 in. long by 12 ft. 4 in. in diameter, having a heating surface of 2,900 square feet. The working pressure is 80 lb. to the square inch. The Irrawaddy Flotilla Co. have a large fleet of steamers of this class for towing their cargo barges between Rangoon and Mandalay, while the vessels at the same time carry passengers and light freights. Each steamer takes two barges in tow alongside. The usual up-river trip takes about five days, while the down-river run is done in two days.—*Engineering.*



LIGHT DRAUGHT STEAMER BURMA, IRRAWADDY FLOTILLA COMPANY, LIMITED.

PROPELLER FOR PLEASURE BOATS.

NUMEROUS attempts have been made at various epochs to render the navigation of pleasure boats upon our rivers accessible to all, and especially to those whose want of strength and practice renders the use of oars too fatiguing or even impossible.

Although the solution of the question has already been presented in many shapes, we have thought that it would be interesting to make known to our readers a new type of propeller devised and constructed by Mr. E. Pombas, a mechanic of Reims. Fig. 1, taken from a photograph, permits of the arrangement being at once understood. The apparatus consists in principle of a sort of paddle hanging vertically at the stern of the boat, and which a series of levers, properly arranged, connects with two vertical rods placed within the boat and movable around a horizontal axis. The person who maneuvers the apparatus seats himself between the two rods, seizes one with each hand, and, giving his body, and especially his arms, a to and fro motion, as if he were rowing, communicates to the paddle, actuated by the levers and cranks, an oscillatory motion rising and descending in a vertical plane.

FIG. 1.—NEW PROPELLER FOR PLEASURE BOATS.

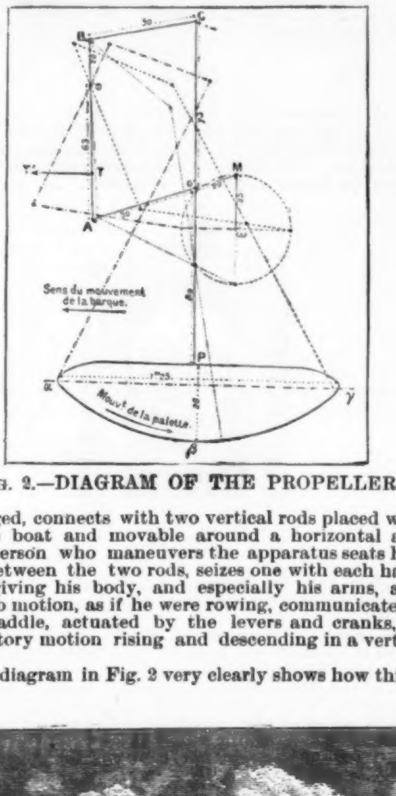


FIG. 2.—DIAGRAM OF THE PROPELLER.

The diagram in Fig. 2 very clearly shows how things work and what is the form of the curve described by the paddle in its motion. The stress exerted by the person in the boat is transmitted through the horizontal rod, TT', to the lever, AB, which is movable around a fixed point of the frame, O. Through the lever, BC, the motion is transmitted to the paddle, CP, jointed at O' with a connecting rod, AM, joining the lever, AB, with a crank, $M\omega$. It is the rotary motion around its center, ω, given by the lever, AB, to this crank that transforms the various angular motions of the levers so that, as a final analysis, the extremity, P, of the paddle describes the curve, $P\alpha\beta\gamma$, composed of two distinct parts, $\alpha\beta\gamma$ and $\gamma P\alpha$.

The effectively useful part of this curve ($\alpha\beta\gamma$) is submerged, that is to say, during this time the paddle is pushing against the water and making the boat advance. The useless part, on the contrary, that which the paddle describes in returning to its starting point ($\gamma P\alpha$), is high and dry, that is to say, during this time the paddle is not touching the water.

The return is therefore very gentle, since it occurs in a medium without appreciable resistance—the air. Moreover, a handwheel keyed upon the shaft of the crank, $M\omega$, so facilitates the motion that the paddle returns of itself to its starting point. The stress developed, therefore, is thus always directly and wholly utilized for making the boat move forward.

The operation of the propeller, as may be seen, imitates that of a pair of ordinary oars. Its useful effect should be at least equal, all else being equal, for it presents, in addition, the advantage of a simple, non-fatiguing maneuver, which, moreover, is heathful to the same degree as that with the use of oars, and which necessitates no special practice.

We shall further remark that the entire light frame that supports the paddle and all the levers necessary, along with the operator's seat, is keyed upon the vertical rod that serves as an axis of rotation to the rudder; so that an insignificant stress of the loins upon one leg or the other, to the right or left, causes the entire frame, and consequently the rudder, to deviate in one direction or the other. The direction is thus always better assured by the person who performs the functions of an oarsman than by the alternate play of two oars.

It is easy to conceive that, instead of placing the propeller at the stern, it might be arranged in each side of the boat.

There would thus doubtless be obtained a little greater speed, but, as the width of the boat would be very sensibly increased, it would become impossible to enter certain narrow passages. Placed at the stern, on the contrary, the propeller leaves every facility in this regard, and this may offer great advantages in certain local conditions.

It is preferable to mount the propeller upon a very stable boat, one with a flat bottom, for example. Under such conditions, it is possible for a woman or a child to perform the functions of an oarsman and steersman very conveniently and without fatigue. In regular daily practice, a man can, according to Mr. Pombas, obtain a speed of 3½ miles an hour.

In addition to his arrangement of a jointed paddle as a propeller for boats, the inventor has devised, upon the same principle, a hydraulic motor of special nature, which, directly and without necessary labors, utilizes the velocity of the current of any river. This important question, as well known, is always the order

of the day, and has already given rise to some interesting experiments. Those undertaken by Mr. Pombas with his extensible and reversible paddle hydromotor are not yet complete enough to allow us to give, with details, the apparatus that he has constructed. However, we can very readily conceive, in principle, that if the current bears against the paddle, things will occur in an order exactly the reverse of that which we have explained, and that the paddle, the motive element, will consequently give rise (thanks to a series of opposite transformations) to a rotary motion utilizable through belts and gearings.

The power of the motor evidently depends upon the strength of the current, on the purchase of each paddle on the water (surface of the paddle by length of the curve, $\alpha\beta\gamma$), and upon the number of paddles; whence a whole series of special arrangements that it is easy to imagine.—*La Nature.*

[Continued from SUPPLEMENT, No. 687, page 10973.]

SIBLEY COLLEGE LECTURES.—1888-89.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

II.—THE GOVERNING PROPORTIONS OF STEAM BOILERS.

By CHAS. E. EMERY, Ph.D., of New York.

IT is believed that the results obtained with the boilers exhibited at the Centennial Exhibition, which include varieties of several known types, may be explained in every instance upon the foregoing principles, and, as a matter of instruction, this will be attempted at this time, though, of course, without reference to the names of the parties interested.

We first, however, examine the drawings of various marine boilers and of an ordinary land boiler, the illustrations for which have, by consent of your worthy director, Prof. Thurston, been taken from his valuable work on steam boilers. Fig. 6 shows a front

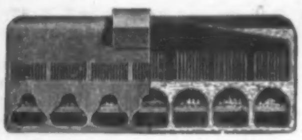


FIG. 6.

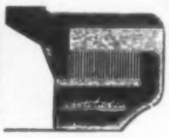


FIG. 6A.

elevation, partly in section, and Fig. 6A a longitudinal section of the type of boiler used in the experiments upon which the curve was chiefly based. It is what is known in the navy as the Martin boiler. The products of combustion pass directly from the fire to a back connection or combustion chamber, thence to the uptake at the front between rows of small vertical brass tubes. As will be seen, the products of combustion travel directly across the heating surfaces of the tubes, a condition found in practice to be best conducive to efficiency. The water circulation is also very perfect, as the water from above the furnace rises directly upward through the vertical tubes, and the water spaces either side of the tube sections and furnaces furnish ample area for the return of the water after the steam has become disengaged at the surface. In such a boiler it is possible to make the spaces between the tubes so large that the principal current of the gases will only move along the top tube sheet and heat the upper portions of the tubes; but by contracting the space between the tubes and arranging them in rows, slightly zigzag in the direction of the flow of gases, but so that the direct projected opening is equal to one-eighth of the grate, it is found that the gases flow nearly uniformly through all parts of the spaces between the tubes, making all the surface efficient. It will be seen how readily the experiments in reducing the heating surface were made with this particular kind of boiler. Rows of tubes were simply cut out at front or rear and the openings plugged. This did not alter the area for draught between the tubes, though, of course, the resistance was reduced by the shorter length of passage the gases were required to take.

Fig. 7 shows a cross section of a horizontal tubular

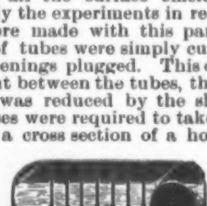


FIG. 7.

marine boiler, corresponding in appearance to the marine boiler shown. In this case the water circulates around the tubes, and the gases pass through them to the uptake. Heating surface along which the products of combustion pass longitudinally, as in fire tubes, is not as efficient as when the flames impinge against water tubes, either vertical or inclined, and used in connection with drums and pipes so as to secure circulation, and for this reason the second curve, P, on the diagrams which have been shown, is lower than the maximum one, O, based on the experiments with the water tube boiler. It is also more difficult in boilers of the horizontal tubular type to obtain precisely the desired proportions, though it is possible to keep the cross area for draught down, so that the gases will be forced to circulate nearly uniformly by using tubes of small diameter. As such tubes choke readily when using soft coal, and on long voyages even with hard coal, it is customary in the merchant service, where the space can be arranged differently than in men of war, to use boilers of the flue and return tubular type shown in Fig. 8. In this case the flames from the fuel first pass through flues in the lower part of the boiler to a back connection, then through tubes to the uptake, the upper part of which is generally surrounded by an annular drum to increase the steam space, called a steam chimney. In such boilers the proper area can be secured by selecting tubes of proper size, and when large sizes are used, the length can be made sufficient to secure the proper relation of heating surface.

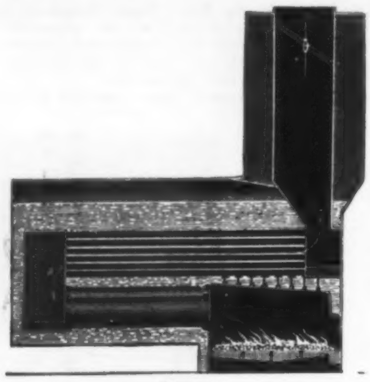


FIG. 8.

The ordinary cylinder tubular land boiler shown in Figs. 9 and 10 has similar features of arrangement and operation to the marine boilers above explained, though the fire here passes underneath the cylindrical shell, and enters horizontal tubes in the same from the

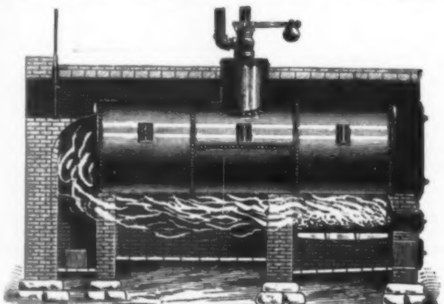


FIG. 9.

rear and escapes at the front, from which it frequently passes directly to the chimney, though in many cases it is carried over the top of the boiler, as shown in the illustration. It is perfectly possible to proportion these boilers to secure maximum efficiency. As explained

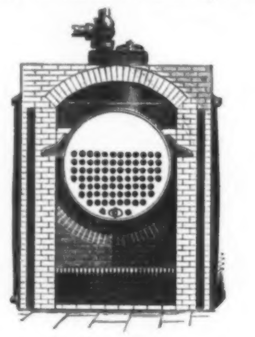


FIG. 10.

hereafter, they are frequently made with tubes larger than is desirable for economy, so as to secure increased power.

The next boiler presented, Fig. 11, is what is known as the Herreshoff coil boiler. By careful construction this boiler has shown remarkable economy for the extent of heating surface it contains. Much of the heating surface is exposed to direct radiation from the fire, and in practice the upper coils are placed so close together that a considerable portion of the heat is forced to find its way out between the side coils, so

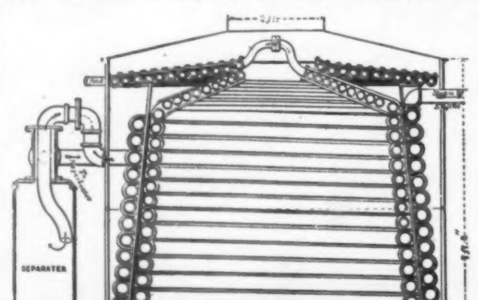


FIG. 11.

that the distribution of heat over the surface is quite satisfactory. Mr. Isherwood's experiments with one of these boilers on the steamer Siesta showed 11·399 units of evaporation per pound of combustible, with a rate of combustion of 0·46 pound of combustible per square foot of heating surface per hour, which is 93·5 per cent. of the results shown by curve, O, representing the maximum practical efficiency as previously stated, when the rate of combustion is considered.

The boiler which, at the Centennial Exhibition, showed results most nearly corresponding to the curve, O, is shown in Figs. 12 and 13, but even this only shows 92·1 per cent. practical efficiency compared with curve, O, indicating, in connection with other performances to be stated, that a reduction of 10 to 15 per cent. is inevitable with customary management. The results with this boiler show that it is not so necessary to restrict the areas through which the gases pass as it is to pro-

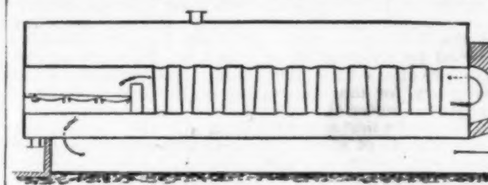


FIG. 12.

duce uniform resistance over the heating surfaces. It will be seen by reference to the drawing that the heating surface is disposed in the form of vertical tapered tubes running across a large tube in continuation of the furnaces. The shape of the tubes not only permits free circulation of the water, but also slightly increases the resistance at the tops of the horizontal flues, so that the gases are forced to move also at the bottom and the flow through the entire section is approximately equalized. The transverse tubes continually break up the current, and the intermediate spaces allow free opportunity for equalization of pressure and complete combustion. The same action as to pressure and resistance

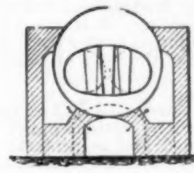


FIG. 13.

takes place in the water tube boiler when the tubes are staggered so as to require the heated gases to take a tortuous course. In boilers of the land type previously shown, the lower surface of the boiler is efficient heating surface, as the gases by their gravity tend to rise against it; but in all cases except in contracted tubes, the heating surface underneath the stream of gases is not very efficient, as the gases rise away from it.

The boiler shown in Figs. 14 and 15 is like an ordinary cylindrical tubular boiler, except that additional heating surface is placed alongside of the furnace, with a view, as it is claimed, of utilizing the heat which is

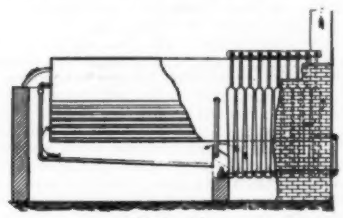


FIG. 14.

radiated to the inclosing walls. A slight consideration of the principles hereinbefore discussed will show that unless the walls are so thin or defective that the heat is really carried away, it must pass on and be utilized in the tubes, and the only effect of putting the tubes into the furnace is to increase the heating surface in the boiler, and such surface must be considered as a whole in relation to the amount of coal consumed. If more coal be burned by increased draught, the additional heating surface will increase the power of the boiler with the same economy as before. If less coal be burned, the additional heating surface will simply produce economy within certain limits; for the combustion can be reduced so low that the fire cannot

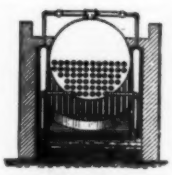


FIG. 15.

be properly taken care of. This boiler, in practice, actually gave results so high that they were questioned, but they were not quite as high, considering the rate of combustion, as some of the other boilers, showing only 90·6 per cent. practical efficiency compared with curve, O.

Another similar boiler shown in Fig. 16, differing only from the ordinary cylindrical tubular boiler in that

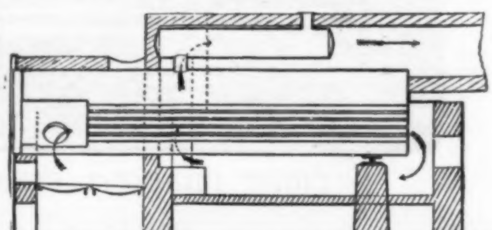


FIG. 16.

the flames enter the tubes at the front, pass through them to the rear, and are carried back underneath the

shell, thence around it to the chimney, is capable of being proportioned and operated to secure excellent results, and so proved in practice. Still it only gave 89·3 per cent. practical efficiency on the basis of the experiments with the naval boiler, part of which is due, of course, to the use of horizontal instead of vertical tubes. Still the results are about the same as the best of the others.

Fig. 17 shows a typical boiler of the kind known as sectional boilers, which are rapidly coming into use. A water level is maintained in the upper drum, the water sinks to the bottom of the inclined tubes through the rear connections, then passes upward and laterally through the tubes and is discharged mingled with steam through the front connections back to the drum again, where the steam is released and the circulation thus kept up regularly. The circulation in this particular form of boiler is excellent, and a fair circulation of gases is also secured by arranging cross partitions, so that the tubes are crossed three times, as shown in the drawing. These boilers are, however, proportioned to give high power for the surface, so the economy tests showed only 90 per cent. of the results with the naval boilers. This is about the same as the best of the other boilers, and this form has many collateral advantages discussed in general elsewhere. The reason it did not give as high results as the naval boilers may be explained on the basis that even with large volumes of gases passing there are corners in each of the tube sections, particularly the first one, through which the

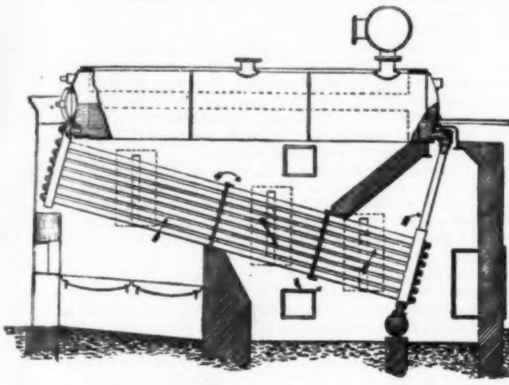


FIG. 17.

currents of hot gases are not obliged to pass in order to reach the chimney on the line of least resistance.

Fig. 18 shows a boiler of similar type, in which the same principles of the circulation of gases are observed. Instead of crossing the tubes three times, but two crossings are made, and the number of tubes in depth is greatly increased. The practical efficiency in this case is 91·4 per cent., or slightly higher than shown by other boilers of this type, which is probably due to the fact that the superheating surface caused a slight economy, though the amount of surface of this kind was not included in this or in any other case, for if it had been, it would have caused all boilers with such surface to show at a considerable comparative disadvantage. In this particular boiler, as usually constructed, free circulation is not obtained in the tubes, and it is claimed that it is not sought. The communications between the tube sections are through comparatively small openings, so that instead of large volumes of water passing through the same to the drum, there is room only for the steam to pass. Curi-

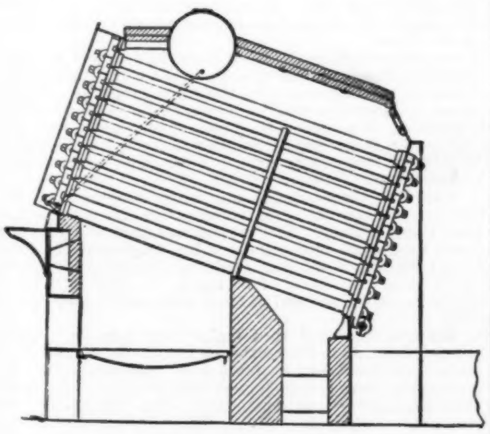


FIG. 18.

ously enough, this restricted circulation operates satisfactorily in many cases. The principle is doubtless the same as obtains in the operation of many locomotive boilers, where the tubes almost entirely fill the lower part of the shell, particularly such as are used in the torpedo boats abroad, where the whole mass of water between the tubes must be in a froth, though but little water is lifted, for the reason that there is no opportunity for a down current, and the steam finds its way through the froth to the surface. Considerable loss of efficiency should be expected, under such circumstances, compared with what would be obtained with the same surface if the water had free opportunity to circulate and disengage its steam at the surface as in ordinary forms of boilers. The objection to this system, particularly with large tubes, is that the quiescent point where sediment deposits seems to come within the tubes themselves, and this fact has caused trouble in some cases.

Fig. 19 represents a similar boiler of the water tube type, in which, however, the distribution of the gases over the surfaces was evidently defective, as only 83·7 per cent. practical efficiency was obtained.

Fig. 20 represents still another boiler of this same general type, but it was not properly proportioned, as it showed only 82·9 per cent. practical efficiency.

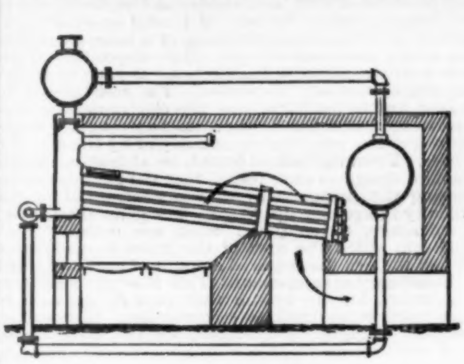


FIG. 19.

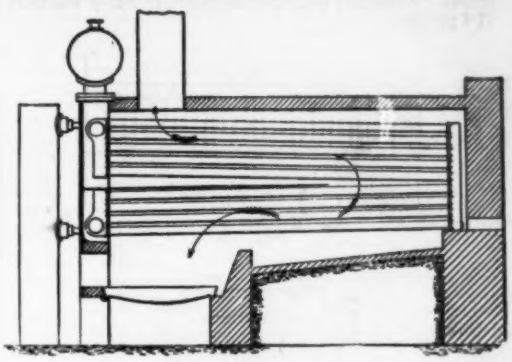


FIG. 20.

Fig. 21 represents a boiler with the same general method of operation, though the water and steam are contained in globes of cast iron, held together by

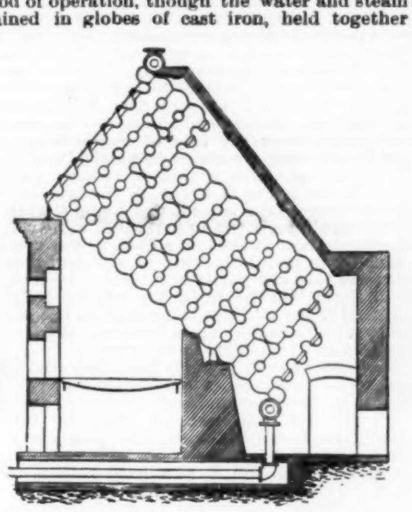


FIG. 21.

bolts. These boilers give good practical results, but it is apparently difficult to distribute the gases equably about the mass of tubes, so as to make all parts of the surface equally efficient. The practical efficiency was 84·7 per cent.

Figs. 22 and 23 represent a type of boilers with pendent tubes, in which the water is contained in vertical tubes with their lower ends closed, circulating tubes being provided inside. These tubes are known as Field tubes, and can be disposed to secure economy.

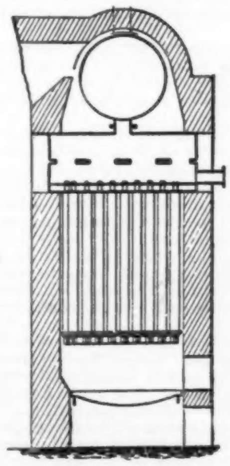


FIG. 22.

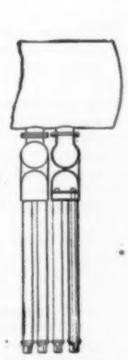


FIG. 23.

In this particular case the spaces between the tubes appear to have been so large that the gases found their way freely to the chimney between few of them, and the result was a practical efficiency of only 85·9 per cent.

Figs. 24 and 25 represent a curious boiler, with inclined tubes each side of the furnace connecting lower and upper drums. Attempts have here been made to carry the gases up and through one section of tubes and down and through another on correct principles. Still the proportions were defective, as the practical efficiency was only 89·1 per cent., which, though about the same as the best, did not warrant such a peculiar construction.

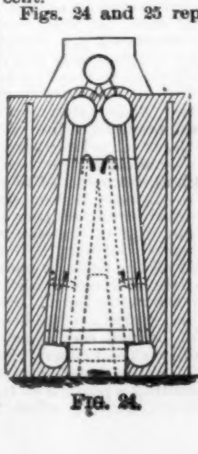


FIG. 24.

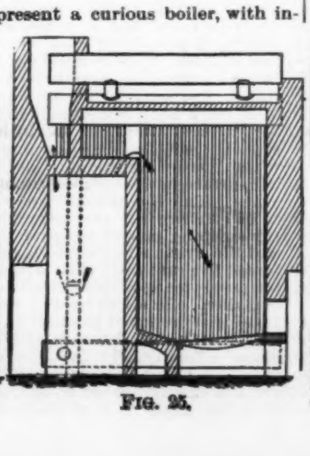


FIG. 25.

Fig. 26 represents a vertical pot or boiler with side tubes connected in the form of loops from the bottom to the top of the shell. Very excellent circulation in the tubes is secured in this way. There are numbers of boilers of this general kind. In a prominent one the tubes run spirally from the bottom of the boiler to near the top, and in another, called distinctively the "Porcupine" boiler, short tubes simply protrude radially from the shell. The difficulty with all these boilers is that with tubes of parallel section, as is necessary, of which the whole or part run radially from the shell, the spaces near the casing are always wider than near the shell, so that the line of least resistance is along the casing directly to the chimney, and all the surface is not effective. Various expedients have been

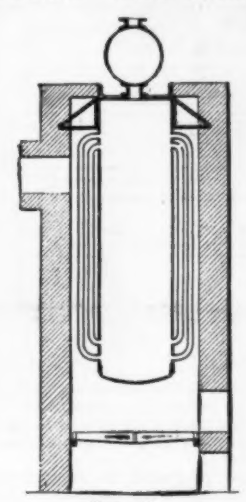


FIG. 26.

tried to overcome these difficulties, and some of these boilers are really giving efficient results. The "Porcupine" form offers great facilities of construction and repair, as the tubes are made of such length that they may be cut out from the inside of the drum, and another replaced in the same way without disturbing the rest of the boiler. Of course the amount of circulation which can take place in short horizontal tubes of this kind is limited, but considerable power is available within the limit. So far as known, no boiler of this general type shows heating surface as efficient as is shown by the curve. The one illustrated gave only 77·8 per cent. practical efficiency compared with the naval tests.

The boiler shown in Figs. 27 and 28, also tested at the exhibition, is of the marine type, with three hori-

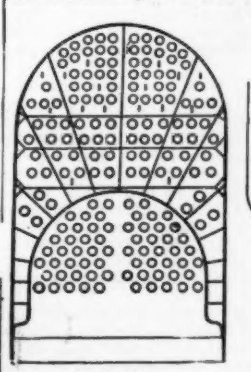


FIG. 27.

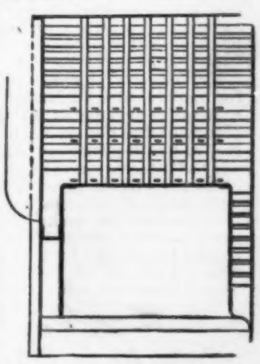


FIG. 28.

zontal rows of tubes, one above the other; two in the water space and one in the steam space. This boiler showed a fair distribution of the gases, though the draught area was large. The result was 84·9 per cent. practical efficiency.

Figs. 29 and 30 show a boiler made up of cast iron sections, arranged transversely and connected at top and bottom; each section being provided with openings arranged in line with each other, so as to imitate in some respects the arrangement of the tubes in an ordinary boiler. Undoubtedly this boiler could have

been proportioned to obtain fair efficiency, but that the draught areas were altogether too large and the gases did not necessarily pass over much of the surface is shown by the fact that the practical efficiency was only 74·6 per cent.

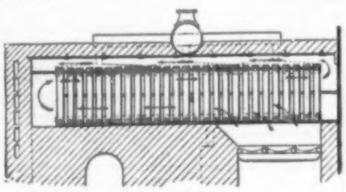


Fig. 29.

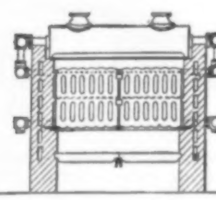


Fig. 30.

Fig. 31 shows a peculiar boiler. It consisted of a horizontal shell continuously rotated on hollow trunnions over a fire. The gases entered a first section of tubes in a jog at one end from a side connection and were discharged through central tubes to a chimney at the same end at which they entered. Rotation secured unquestionable circulation of the water, and doubtless such a boiler could be proportioned to give excellent

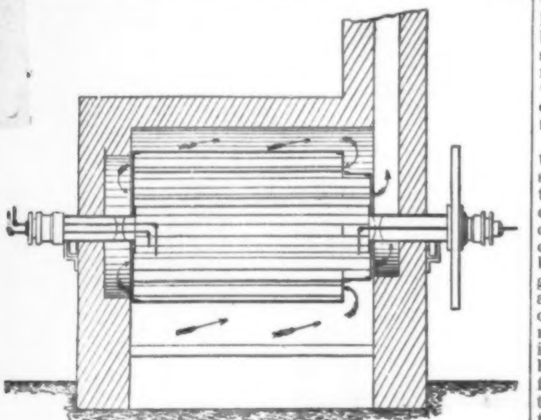


Fig. 31.

results provided the leakages between the several passages could be practically prevented. Either leakage occurred in this particular case or there was some difficulty in the proportions, as the practical efficiency was only 83·7 per cent.

We are now prepared to re-examine the original curve in connection with general remarks on the subject of boiler proportions. Land boilers are ordinarily operated between the limits of 0·25 to 0·4 pound of combustible per square foot of heating surface. Marine boilers are generally worked up to between 0·4 and 0·6 pound on same basis, or to between 13 and 17 pounds of coal per square foot of grate. In ordinary land boilers it is customary to provide a draught area ⅙ to ⅛ of the grate and sometimes more. Plain cylinder boilers frequently do not have more than 11 square feet of heating surface per square foot of grate, and yet will evaporate 7 pounds of water under average conditions, as may be ascertained by reducing the quantities in tables to such conditions. Cylindrical boilers with flues have on the average about 18 square feet of heating surface per square foot of grate and will evaporate about 8 pounds of water under fair average conditions. Cylindrical tubular boilers, like the drawings shown, are variously proportioned so as to have 20, 25, 30, and even as high as 35, and in exceptional cases 45 square feet of heating surface per square foot of grate. With 30 feet and upward an evaporation of 9 pounds can be depended upon under average conditions with good fuel.

Mr. Isherwood recommends as a good compromise for marine boilers a draught area of $\frac{1}{8}$ of the grate and a heating surface of 25 times the grate. There are plenty of flue boilers running with only 16 to 18 square feet of heating surface per square foot of grate, giving very satisfactory results on account of the high power obtained with a given weight. In cylindrical boilers with internal furnaces, sometimes called Scotch boilers, it is common to make the draught area ⅛ to ⅙ of the grate, which enables 17 to 20 pounds of coal to be consumed per square foot of grate, so that the consumption per square foot of heating surface is not very different from that with other boilers.

In all cases the draught area so far controls the coal-burning capacity, which is the chief factor in relation to the power of a boiler, that the writer bases all his calculations on the relation of the cross area of tubes to the heating surface. One square foot of cross area to 200 square feet of heating surface represents the typical marine boiler with a fairly free draught and good economy. One to 160 or 180 represents a freer boiler of less weight, like flue boilers, and one to 240 a boiler which should give good economy where a good draught can be secured and all details of design and arrangement receive proper attention.

It is common for designers to attempt to secure better economical results by lengthening the tubes or otherwise increasing the heating surface without providing at the same time increased draught to balance the increased resistance. This condition has its prototype in other branches of science. A given amount of heating surface disposed in boilers with short tubes is akin to coupling electrically in "multiple arc," to the extent at least that in the latter case a large current may be secured with low electro-motive force, and in the former a large volume of heated gases are conducted, involving the combustion of a large amount of coal with a moderate draught. The disposition of the same heating surface in longer tubes is somewhat like coupling electrically "in series." The resistance is increased, and in the latter case the electro-motive force must be increased, and in the former a stronger draught secured, either with higher chimney or by the use of a blower. From the lack of forced, or at least an ample draught, designers have found that the gain due to increasing the heating surface was neutralized by the difficulty in keeping up steam. The general tendency is, therefore, to construct what are called "free" boilers, in which the area of the tubes is made large enough to burn the required amount of coal easily and with ordinary management. This is often conducive to economy, for the reason that men do not have to work the fires as hard to secure steam. If, however, sufficient draught be provided, or moderate forced blast, there is no trouble obtaining the full efficiency from boilers designed to secure economy. In ordinary competition in the market those parties sell most boilers who guarantee a certain power for the least money. There are firms which have found that by putting in 4 inch tubes in an ordinary land boiler, not over 16 feet in length, they gain in power, or obtain a certain power so much more easily, that they furnish them regularly, and only the coal piles of the users suffer, though not to any very large extent. As will be seen from the figures in naval boilers of natural draught, it is much better to make them free, so that the maximum power can be obtained and some economy secured by simply reducing the rate of combustion at other times, though they are not as economical as they would be if the draught area were kept reduced so that the gases were obliged to flow over all the heating surface. In former naval experience it was found that the gases which pass through the upper tubes were very much hotter than those in the lower ones, as was ascertained by putting in metals melting at different points. In some cases this was partially remedied by putting ferrules in the ends of the tubes. The practice of Mr. Isherwood during the war was to proportion the boilers for economy. So a larger number were required, and very much space was occupied in the vessel.

The more general practice has been and still continues to be in most cases to make the boilers "free" as stated in reference to land boilers, though a reaction is taking place on the basis of designing boilers for economy and securing the required power with forced draught. Such an arrangement adds complication in ordinary practice. So it is a good rule, in designing boilers for competition with others, not to depart greatly from the proportions or methods of operation already in use without special authority from the owners, after telling them that a reasonable economy, much more than sufficient to pay the interest on the increased cost, can be obtained even without the use of blowers by putting in boilers with larger heating surface and somewhat restricted draught area, and that this will reduce the power of boilers of a certain size so that more will be required. The most successful of the sectional boiler makers have had to make them quite free, so that, while they give fair results, they cannot be called extraordinary. In compensation, such boilers can be forced far above their rated capacity, and therefore give better satisfaction as a general rule than if proportioned to secure a little economy with very great reduction in the facility of getting and maintaining steam.

The curves and table are particularly instructive, also, as showing what can be done in the construction of steam boilers of very little weight for temporary use, such as are used in steam fire engines, torpedo boats, and the like.

Boilers of some of the little steam launches, which do not carry this principle nearly as far as has been shown by experiment to be practicable, have been called phenomenal. One, for instance, the Buzz, developed nearly 200 horse power in a mere open launch about 50 feet long, and in torpedo boats 450 horse power has been obtained from a locomotive boiler only 6 feet 6 inches in diameter. As forced draught is used in these cases, and the boilers contain small tubes to secure a large amount of heating surface, the results are closely comparable to those obtained with a railroad locomotive.

It has been already stated that for rates of 0·2 and 0·8 pound of combustible per square foot of heating surface per hour, the same power would be developed at the higher rate with $\frac{1}{4}$ the heating surface required for the first at an expenditure of only ⅙ additional fuel. The curves and tables show that phenomenal results for special purposes above mentioned may be secured by returning nearer and nearer to the sap kettles of our ancestors, where there was little heating surface, but a large fire (and, by the way, it may be said plenty of smoke to persecute those of the rising generation who wished to sample the concentrated sap). By comparing the results with 0·4 and 4·0 pounds of combustible per square foot of heating surface, it will be seen that in the latter case the same power will be produced with $\frac{1}{15}$ of the heating surface by burning only $2\frac{1}{5}$ times as much fuel as in the first case. If, with such boilers, 12 pounds of coal were consumed per square foot of grate, there would be required 30 square feet of heating surface per square foot of grate in the first instance, and only three square feet in the second, or little more than is available in the furnace itself, thus securing a minimum of weight independent of fuel consumed. Some of the escaping heat may be utilized without much additional weight by adding superheating surface in the uptake, though at some risk of reliability. This is commonly done in ordinary boilers, but to be efficient it is necessary that the temperature of the escaping gases be higher than that of the steam, and the system is, therefore, adapted only for boilers forced to practically their utmost all the time, or those purposely made with reduced heating surface, as above explained. In all devices of this character large, thick tubes are preferred to small tubes, which are liable in this location to be corroded or burned out, so as to cause difficulty. In fact, the only superheaters used in boilers about the harbor and on many marine steamers are simply formed by surrounding a portion of the chimney itself with a steam drum, making what is called a steam chimney. Students of the subject will find in Mr. Isherwood's works a full statement of experiments with superheating apparatus on the Chesapeake Bay steamers Georgeanna and Adelaide, which showed very important economies, and yet that apparatus, which consisted of a mass of small tubes in the uptake, was not replaced when the vessels were repaired, and the construction has not been duplicated elsewhere, for the reason that it involved so much expense and attendance in the way of repairs that it was not considered advisable.

Later experiments seem to show that there is a gain in the use of high air pressures in the ashpits of boilers independent of the increased volume of air, which is readily explained on the basis that the air is of greater density and more oxygen is supplied with a given volume. Some designers reduce the area of the smoke pipe by a damper or a grating arranged to partially cover the ends of the tubes, so that a higher pressure may be maintained in the ashpit to secure the result referred to. At the higher steam pressures which are, moreover, coming into vogue, the gases are necessarily discharged at somewhat higher temperatures, and particularly so on steamers, where it is desired to get the boilers as free as possible, so as to reduce the weight. There are now a number of cases where the waste gases are used to heat the air supplied to the ashpits, and in this way utilize a portion of the waste heat. This has been tried for ordinary boilers and important economy secured, but it involved so much in the way of detail and extra attendance that it has never been popular. It is, however, being revived, particularly in connection with increased pressure in the ashpits before referred to. It has been said that "history repeats itself." So in mechanical engineering one development modifies another to such an extent that old ideas, which in former times had been deemed impracticable, are being constantly revived, and with modified details, or in new combinations, secure very favorable and desirable results.

The foregoing, on but one of the many interesting problems in connection with boiler design and construction, will give those present an idea of the magnitude of the general subject. All that has been told is preliminary to the design itself, which involves not only proper proportions, but the selection of a plan adapted to the work to be done, the adjustment of sizes to suit the power required, the disposition of available materials to secure proper strength and durability, the preparation of detail plans embodying these features, and, finally, all the details of inspection and construction to secure a structure such as the designer had in mind. A short time since there was no complete work on this subject which would enable the student and practical man to design, superintend, or construct boilers as they should be, but the want has been recently supplied by your director, Prof. Thurston, and the speaker wishes to add his testimony to the great value of the work. This lecture has attempted to deal with one branch of the preliminary principles more in detail than could possibly be done in any general treatise, and it is hoped that the remarks may add interest to the study of the whole subject with the increased facilities now available.

We close with hearty thanks to all present for their kind and earnest attention.

BRICK STREET PAVEMENTS.

At the late Memphis meeting of the National Association of Brickmakers, a paper on the general subject of brick street paving, by Mr. J. J. W. Billingsly, was read, of which the following is an abstract.

Latterly, in this country, the use of brick for paving streets has been receiving some attention. Sixteen years ago, at Charleston, W. Va., they put down a few squares of brick pavement, which have been subjected to heavy travel, and we are informed that they have stood the wear well. Since they have tested them they are generally improving their streets by paving them with brick.

At Steubenville, O., they have had a test of eight years on the principal street of that city. The endurance so far has exceeded the most sanguine expectations. The writer visited Steubenville in May last and examined the street that was first paved, and was agreeably surprised to see that it looked as though it had been laid only a year or two. The wear of eight years was hardly perceptible.

Fourteen years ago Mr. Heafer, of Bloomington, Ill., laid one square of brick pavement on the west side of the Court House. The writer has frequently visited that city since that time and has examined the pavement, finding it all that could be desired. Since they have been convinced of its merit, the city authorities have improved several of their principal streets in this way.

We are informed that Galesburg, Lincoln, Peoria, Springfield, and other cities in Illinois have put down many miles of brick pavement. Decatur, Ill., has several miles of streets paved with brick, to the writer's own knowledge. In fact, all of their principal streets have been thus improved. This city commenced the use of brick eight years ago. At one time they had five miles of their streets and sidewalks under contract for brick pavement. In Ohio brick is being generally introduced in the smaller towns and cities—at Columbus, Cleveland, Akron, and other places.

We have heard of no dissatisfaction where hard burned brick have been used. We heard of one square that was paved in part with soft brick, in Columbus, Ohio, by some interested stone contractors, that was taken up and replaced with West Virginia hard burned to keep up the reputation of the pavement. Within the past year a section of one of the principal streets in Washington, D. C., has been paved with West Virginia paving brick.

It is no innovation of the past decade of years. It is no new-fangled invention gotten up by hard pressed brick makers to tide over a dull period in their business. It is not a new thing in this country, and it is less so in the Old World.

Prof. Roberts, of Cornell University, N. Y., a year ago, in a conversation with the writer, said: "I wonder that our people do not use more brick in the improvement of our streets and highways. In the Netherlands the highways are generally paved with brick. In a ride of several days through the country, visiting various herds of Jersey cattle, I did not drive over more than six or eight miles of dirt road. Some

of the highways have been paved for more than half a century, and they require little repair and make splendid roads to travel over."

The brick should be hard and not easily chipped or crushed. There is no denying the fact that some clays are better adapted to the manufacture of pavers than other clays, but it is also true that in many localities clays may be found that are well adapted to this use—clays that will burn to a hard body, having a tough fiber (if the term "fiber" is admissible in distinguishing the adhesiveness or toughness of the product).

There are large brick plants in eastern Ohio and West Virginia that make a specialty of the manufacture of paving brick. We are further informed that they make a specialty of the manufacture of pavers at Galesburg, Ill. The Decatur Tile and Brick Works, of Decatur, Ill., manufacture them in large quantities. But it is also true that in the burning of common brick a great many pavers might be selected from the kilns. We feel free to say that clays well adapted to the manufacture of this desirable product are so abundant that no one manufacturer is likely to have a monopoly of the business in any very large section of the country.

Brick pavements are desirable for the following reasons:

1st. They make a smooth pavement over which heavy loads may be drawn without a jolt. Draught horses are able to draw a third larger load over such a pavement than over a bowlder or rough stone pavement. In addition, both team and wagon are subjected to less wear. For light vehicles there is a most striking comparison. It is a pleasure to sweep along without a jolt or a jar over the smooth, springy brick pavement, and a tribulation to drive over the cobble or rough stones.

2d. Brick pavements are desirable because they are durable. The many instances already referred to are sufficient without adding another.

3d. The abundance of the material that is at hand—every street, sidewalk, and highway may be paved with brick, and an abundance of material would be left in store.

4th. Brick pavements are easily repaired. There is not a pavement that can be named that can be so easily repaired as brick. If a single brick is too soft, replace it with another, and the work is done.

5th. Brick pavements are less expensive than others, if durability, wear and tear of teams, vehicles and comfort are taken into account. The cost of construction ranges from $1 to $1.40 per square yard.

To construct such a pavement properly, the roadbed should be first of all crowned a little and well underdrained; no springy or spouty places should be allowed to interfere with the solidity of the foundation. This may be done with a tile drain at the foot of the crown, on each side of the roadway or street. To a solid roadbed add three or four inches of sand, then a layer of brick laid flat, two inches more of sand, followed with a layer of brick set on edge, and the interstices filled with sand, and a small covering of sand on top. The latter will soon wear off. Another method is to set one layer of brick on the four inches of sand, and settle with mauls and cover with sand as before. This is the cheaper method and is good enough. Where sand cannot be had in sufficient quantity, the bed for the brick is made smooth and even and soft, or pulverized for one or two inches on the surface, the brick set on edge and settled a little, and the joints or interstices filled with the fine earth. Again, others use plank laid upon a roadbed brought to the desired grade, placing the plank upon sand or upon a clay bed, setting the brick on edge in a light layer of sand, then filling the interstices as before.

SIR WILLIAM THOMSON.

WE publish this week a portrait of Sir William Thomson, recently (and for the second time) elected President of the Institution of Electrical Engineers.

Sir William Thomson, though of Scotch descent, is an Irishman by birth. He was born in Belfast in June, 1824. For several generations his family had occupied a farm near Ballynahinch, in the County of Down; but his father, Dr. James Thomson, a very remarkable man and a born mathematician, managed to secure for himself an education at Glasgow University (traveling was not so easy in those days as it is now, and colleges were not so plentiful), and subsequently he became Professor of Mathematics at the Royal Belfast Academical Institution, and at a later date in the University of Glasgow itself. It was while Dr. James Thomson was professor in Belfast that William Thomson was born, and he was eight years of age when his father removed to the old College in the High Street, Glasgow.

The children of Dr. James Thomson were educated by himself so long as they were children; and they seem to have early imbibed a taste for learning of every kind and much sound knowledge of the most diversified nature. At a very early age William Thomson and his elder brother, James (now Professor of Civil Engineering), were at Glasgow College together, and both are well remembered by those who were their class fellows. William Thomson was specially remarkable—an enthusiastic, eager little lad of twelve—jumping up to answer *viva voce* questions, when his chief difficulty was to make himself seen among his older class fellows.

From Glasgow William Thomson went to St. Peter's College, Cambridge, and in 1845 he graduated as Second Wrangler and first Smith's Prizeman; and he was elected a Fellow of his College. At Cambridge his main work was, it is needless to say, mathematical; but his tastes were by no means confined to this subject of his choice. Literature of all sorts and music had great attractions for him; and athletics were not neglected. He was president of the Cambridge University Musical Society for a time; and he won the Colquhoun Silver Sculls the first time they were rowed for at Cambridge. Anything "with water in it" has a fascination for him—swimming, rowing, sailing, steaming, the Atlantic waves, his own Netherhall burn, the "rivulet down Trumpington Street," the capillary ripples made by a fishing line which is moved through a placid sea.

Even before his Glasgow student days came to an end we find Sir William Thomson's original work in science had commenced; and his first mathematical papers, written before he entered Cambridge as an undergraduate, are well worthy of attention. They were both connected with the Fourier Mathematics, then but little known; and these early studies have probably given a color to much of his subsequent work. In a paper which was published in 1842, in the Cambridge and Dublin *Mathematical Journal*, on "The Uniform Motion of Heat in Homogeneous Solid Bodies, and its Connection with the Mathematical Theory of Electricity"—written at the age of seventeen—he points out the analogy between certain problems in conduction of heat and in the mathematical theory of electricity and magnetism; and he shows how to make use of solutions of the one set of problems in order to establish important conclusions with regard to the other class of questions.

The papers just mentioned were followed by a paper on "Linear Motion of Heat," which contained principles which he subsequently so powerfully applied to the question of "Geological Time." This was also published in 1842, and in 1845 he communicated to Liouville's *Journal de Mathematiques* a paper on the "Elementary Laws of Statical Electricity." In October, 1845, and in June, 1846, he contributed to the same journal a letter addressed to Liouville, and an elaborate paper on his principle of "Electric Images," a subject on which he seems to have spoken to the veteran mathematician during his residence in Paris about that time.

It is impossible, within the limits of the present notice, to discuss or even mention the many papers which flowed from the pen of Thomson about this time; but two somewhat general remarks which will be interesting to electricians may be made with respect to them. In the first place, the years about which we speak just now were of high interest and importance in the history of electric and magnetic science. The discoveries of Faraday in electro-statics and magnetism, and the ideas introduced by him, had given a new mode of thinking of some of these subjects. The subject were communicated to the Royal Society of Edinburgh. The first of these was published in 1849. Thomson was among the first to appreciate the importance of the work of Joule; and his earliest paper on thermo-dynamics is occupied with a critical study of Carnot's "Reflexions sur la Puissance Motrice du Feu," published in 1824, and shows how the theory of Carnot may be altered so as to correspond with the modern doctrine regarding the nature of heat. His series of papers on the subject of thermo-dynamics just mentioned form one of the most valuable and most remarkable of all the contributions with which Sir William Thomson has enriched physical science. The principle of dissipation of energy was announced in 1852; and in connection with these mathematical researches experimental determinations were undertaken by Joule and Thomson, and more than one joint paper of high value was contributed to science by these two lifelong friends.

In 1855 was published Sir William Thomson's paper on "Electro-Dynamic Qualities of Metals." It was given to the Royal Society, and was made the Bakerian lecture for the year. It was while he was engaged in experimental work in connection with this research that Sir William Thomson began to make use of the assistance of his students; and this was the commencement of the Physical Laboratory of the University of Glasgow, which was in fact the first of physical laboratories.

The Bakerian lecture has been followed from time to time by papers on the same subject, and the lecture itself and its continuations have proved a veritable nursery garden from which healthy seedlings have been transplanted in all directions—in Scotland, to England and Germany, and even to far Japan. And, being nurtured and carefully tended, these have grown into goodly plants, greatly to the honor and glory of their cultivators.

Yours truly
William Thomson

function of the dielectric had been recently discovered and traced out, and the doctrine of lines of force had been expounded. Henceforward, action at a distance, so far as electricity and magnetism were concerned, was, so to speak, a notion of the past—an hypothesis utterly untenable and incapable of representing the facts of the case. Thomson eagerly grasped this truth; and making the new knowledge the basis of his mathematical investigations, gave to its expression a mathematical form which endued it with fresh power.

The second general remark that we would make is this: At the age of seventeen, Thomson, as we have seen, devoted himself to the study of attraction, and in his earliest papers gave a large number of important general theories connected with this subject. The results of these investigations were very soon translated into the language of "the potential;" and the connection was established between these results and the theories connected with the science of energy, which was coming into prominence through the labors of Joule. Thus it was that Thomson, at the age of twenty-one, became the exponent of doctrines, the full value of which can scarcely be said to have been appreciated before he was double that age. In 1867, or about that time, the word "potential," now so familiar to students and the merest beginners in electrical science, was unknown, except to a few mathematicians of the more advanced type. Can the Society of Telegraph Engineers picture to itself the benighted condition of an electrical world like that?

In 1846 Thomson was elected Professor of Natural Philosophy in the University of Glasgow; and thus at twenty-two he was appointed to the chair which he has filled with such distinction and continues to hold. More than one offer has been made to him, the most tempting of which have been offers from the English university for which he entertains so affectionate a regard; but he has preferred to remain in his northern professorship, and his constancy is appreciated by the university which he adorns.

The dynamical theory of heat early engaged the attention of Sir William Thomson. His papers on this

In 1855 and 1856 a new field opened itself to the genius of Thomson. The problem of ocean telegraphy had presented itself to the world, and very soon he was practically called upon to solve it. To give a complete history of this time, interesting as it is to electricians, is beyond our present limits. A brief sketch must suffice.

Following up the 1854 experiments of Faraday, Thomson had investigated mathematically the subject of *the retardation of signals*, and had given the *law of squares*, now so familiar to all telegraphers. When the possibility of laying down an Atlantic cable came to be discussed, it therefore became evident that a cable of such a length as 2,000 miles, unless of unprecedentedly large transverse dimensions, might prove a commercial failure on account of the slowness of the transmission of signals through it. Mr. Whitehouse, however, at the Cheltenham meeting of the British Association (1856), endeavored to disprove the law, and to show that much more speedy transmission of signals might, than according to it, be expected.

In September and October, 1856, we find Thomson answering the statements of Whitehouse in two letters to the *Athenæum*. These letters, if there were space at our command, we would gladly quote, on account of the interest of this piece of telegraph history. We must content ourselves, however, with a single sentence from one of them, which gives the key to Sir William Thomson's two years later solution of the retardation difficulty. In his letter to the *Athenæum* of October 24, 1856, the following remarkable sentence occurs (*after* he has made very clear indeed the difficulties to be expected): . . . "Although I have never been able to learn any particulars as to the experience of those who worked that telegraph (Varna and Balaklava cable), I have the best possible reason now for knowing that, if nine letters per second have not been delivered by it, the fault, or rather, I should say, the deficiency, has not been in the cable, but in the instruments." A week later, December 11, 1856, a short paper was communicated to the Royal Society, "On Practical Methods for Signaling by the Electric Telegraph."

The warnings of Thomson were not, however, accepted, and it was only when the 1858 cable was *completed* that the directors became thoroughly alive to the situation. Whitehouse, experimenting on the cable itself with the Morse instrument, and endeavoring to transmit a column of the *Times*, found that he was unable to send through it at the rate of *one word per minute*. Then the directors sent for Thomson, and demanded of him that he would give them, according to his knowledge and his promise, an instrument which should satisfy the conditions necessary for success.

Thomson, experimenting with the reflection of the image of a candle thrown from his concave eyeglass on a sheet of white paper in a fairly lighted room, judged that the flame of a paraffin lamp reflected from a silvered mirror of one-tenth of that area would give an image bright enough for conveniently reading telegraphic signals. This was the first idea of the mirror galvanometer. The trials were made in February, 1858, and the mirrors and the instruments were made by Mr. James White, a Glasgow optician, whose name is now familiar to every electrician. The mirror galvanometer was supplied for the 1858 cable. The directors of the Atlantic company insisted that Thomson should go to sea with the expedition, and also that he should take a patent for his instrument. This was done, and the patent then taken out was the first of Thomson's many patented inventions. To take a patent was somewhat against his wishes. He was ready freely to give to the public the fruit of his labors; and the same remark applies to at least two others of his most remarkable inventions—the sounding machine and the mariner's compass. Sounding by pianoforte wire was offered to the Admiralty, and was described in the *Times* directly after the loss of the Schiller, and the compass was also freely offered; but he found in each case that the only way of securing attention to inventions of importance was to patent them and work the patents. Returning to ocean telegraphy: In 1867 the siphon recorder was invented and patented, and three years later was brought into very general use. Up to the present time these two are the only instruments by means of which signals are read on the long submarine lines.

We have just mentioned the sounding machine and the mariner's compass. The perfecting of these instruments gave Sir William Thomson much labor and thought through the years from 1872 to 1876. Both of these inventions were made to fulfill demands which he had seen to be urgent, partly in the course of his cable-laying expeditions, and partly through his knowledge of navigation, a subject in which he has always taken a very deep interest. In 1876, with the same thought at heart, he published "Tables for Facilitating the Use of Sumner's Method for Finding the Place of a Ship at Sea." The general adoption of Sumner's method thus made simple for the navigator would be a reform in navigation greatly to be desired.

Space fails us to give a full account of Sir William Thomson's more recent work. For five or six years his inventive genius has occupied itself with problems in electricity transcending in difficulty, we may safely say, any previously offered to inventors. To produce instruments capable of being used in the still novel work of electric lighting and electric transmission of power is the question of the day for many minds of high order. If we content ourselves with a one per cent. accuracy, or an accuracy of 1½ per cent., the problem is, perhaps, not too difficult to be satisfied with somewhat ordinary instruments, though most of the measuring instruments at present offered to users will scarcely be found to be reliable to this extent when fairly tested. Sir William Thomson, however, is not content with a standard so inferior; and his electric balances, which have recently and from time to time been described in these pages, certainly reach a far higher degree of trustworthiness.

A mere mention must now suffice of some interesting points in Sir William Thomson's history. In 1876 he was, in Philadelphia, a judge at the centennial exhibition. In 1880 he was, at Paris, a delegate to the Electrical Standards Conference, and at this time he was decorated Commander of the Legion of Honor of France. In 1883 he was in Vienna, at the international exhibition; and in 1884 he received from Berlin the *Ordre pour le merite*. In 1884 he once more crossed the Atlantic to deliver a course of lectures "On Molecular Dynamics," at Baltimore, to a class composed mainly of professors from different parts of the world, gathered together at the Johns Hopkins University.

Sir William Thomson is an honorary graduate of half the universities in Europe. He is a Fellow of the Royal Society, President of the Royal Society of Edinburgh, Member of the Institut de France, the Accademia dei Lincei at Rome, the Berlin Academy, as has been already mentioned, the Amsterdam Koninklijke Akademie, the American Academy of Arts and Sciences. He has a multitude of medals, gold, silver, bronze, iron, awarded for various papers and inventions, and numbers of addresses of greeting and congratulation.

Of himself, we will only say that his genius is at the least equaled by his gentle kindness and his single-minded modesty of disposition. These qualities are conspicuous in his daily intercourse with his students and his younger fellow-workers; and they make him the most beloved of teachers and associates.—*The Electrician.*

TO BLEACH SPONGES.—First wash well in cold water; then immerse in a bath composed of 2 drachms of permanganate of potash and 1 ounce of strong sulphuric acid to the gallon of water. The duration of the immersion varies according to the size of the sponge, etc.

To obtain the color so much admired, wash well in soda water, then immerse the sponge in a solution of carbonate of potash (4 ounces to the gallon) until you have hit the color, then wash and dry.

THE DETROIT STORAGE BATTERY.

So many are the possible applications of a successful secondary battery, that there is no question more interesting to electricians to-day than the satisfactory solution of the storage battery problem. The storage battery of the future will play an important part in connection with street railways, central and isolated lighting, boat propulsion, signal bells, small motors for driving sewing machines, ventilating fans, and numberless other purposes. Hundreds of thousands of dollars have been spent on storage battery experiment work, and genuine progress has been made in the right direction, and batteries are now in daily use on a limited scale for many of the purposes mentioned above.

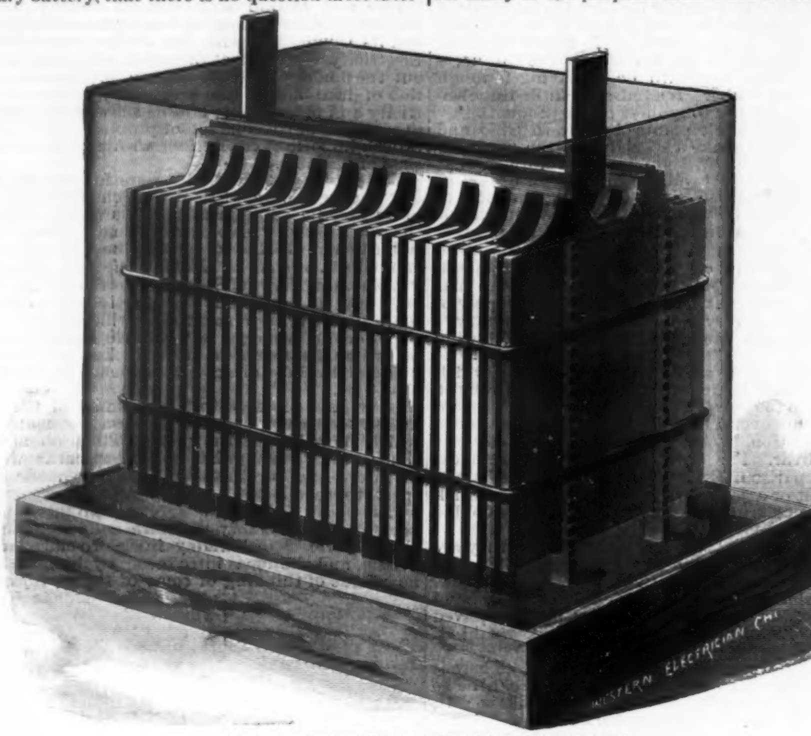


FIG. 1.—DETROIT STORAGE BATTERY.

The Detroit storage battery, illustrated herewith, and manufactured by the Woodward Electrical Company of Detroit, Mich., is a new candidate for popular favor, which certainly possesses many distinctive and valuable features.

At first sight the battery does not seem to differ much from other storage batteries, but on close inves-

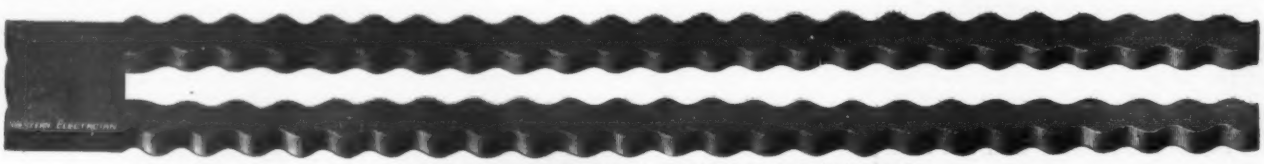


FIG. 2.—DETROIT STORAGE BATTERY—THE DIVIDER.

FIG. 3.—DETROIT STORAGE BATTERY—THE PLATE.

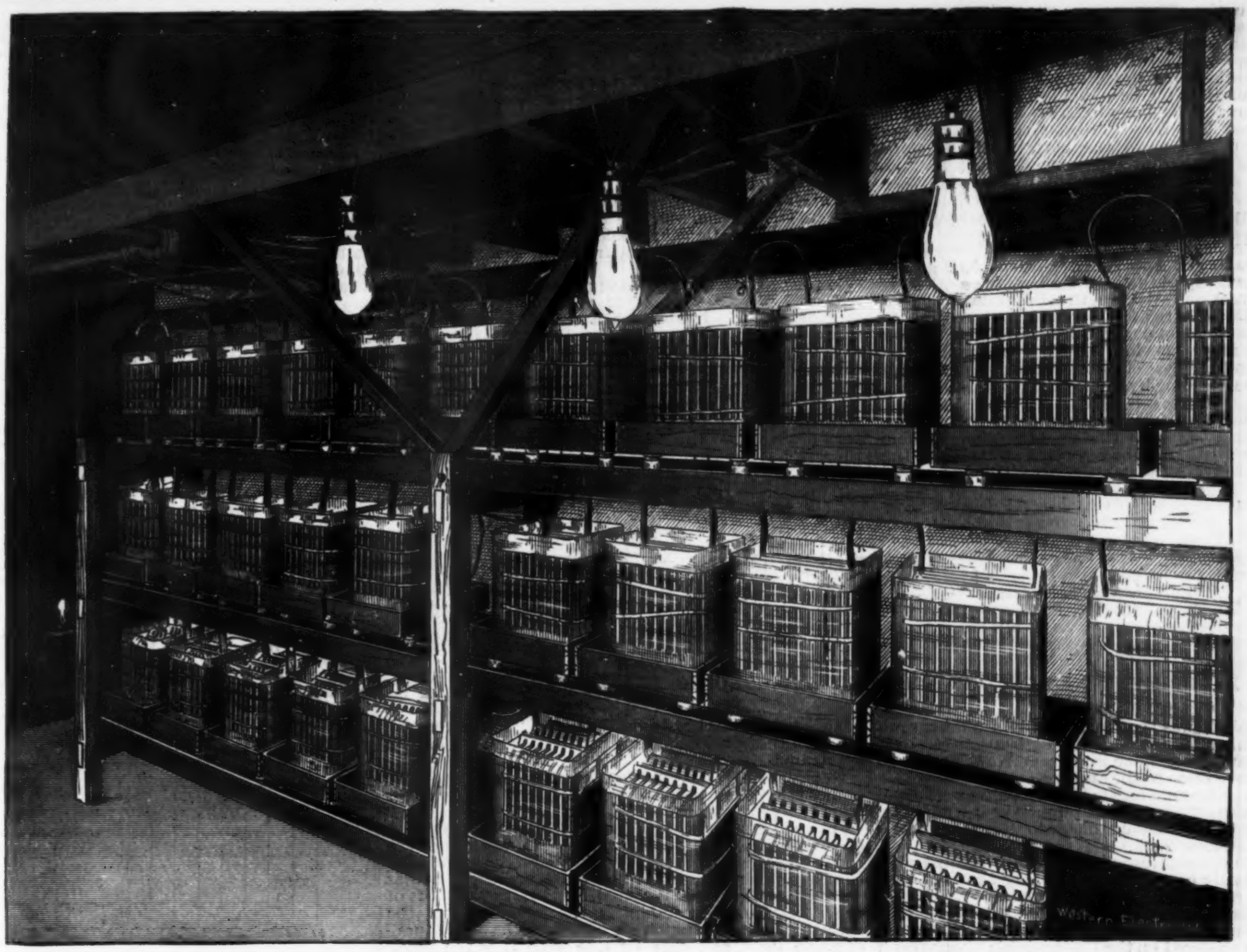


FIG. 4.—DETROIT STORAGE BATTERY—INSTALLATION AT PROF. ELISHA GRAY'S LABORATORY.

FIG. 5.—DETROIT STORAGE BATTERY—INSTALLATION AT THE FACTORY OF THE WESTERN ELECTRIC COMPANY.

tigation it is found that the surfaces of the lead plates present a very peculiar appearance. These plates are made in the following way, which, as will be seen, is entirely different from any process by which plates for other storage batteries are made: A mould of the requisite size—say ten inches high, ten inches wide, and ten inches long—is filled with large crystals of common salt. Molten lead is then poured in the mould. The metal will, of course, readily penetrate the spaces between the crystals, which are embedded in the molten mass.

When the mass cools it is sawed into disks of the desired thickness, and the plates are placed in water to dissolve the salt. When this has been accomplished, the plates are full of irregular cavities of the form of the salt crystals. This appearance of the surface of the plate is excellently shown in Fig. 3, which is actual size.

The active matter, oxide of lead, commonly known as red lead, or minium, is put into the cavities. It will be readily seen that, as the irregular spaces which had been occupied by the salt are larger inside than outside, the active material cannot drop out. These plates are formed and connected in the usual way, and the positive and negative electrodes are insulated from each other by hard rubber dividers in the shape of corrugated forks, as illustrated in Fig. 2. The closed end of the fork is put at the bottom; thus each plate is independently supported by two of these forks. The claim is made that these plates are particularly adapted for traction purposes for the following reasons:

First.—The plates possess great solidity, which enables the cell to withstand the hard usage it is liable to encounter in working railroads and street cars.

Second.—The positive plates do not buckle.

Third.—The plates are constructed of porous lead; the pores are filled with the active material, and, being of a wedge-shape form, it is quite impossible for the parts to be shaken out by the vibration or jolting of the car.

Fourth.—These cells will withstand high rates of discharge, which is necessary in starting cars or ascending steep grades.

The cells are made in six different sizes, as indicated in the following table:

Type.	Working Rate in Amperes.		Capacity. in Ampere Hours.	External Dimensions, in Inches.			Weight Complete in Pounds.
	Charge.	Discharge		Height.	Width.	Length.	
25M	35–45	1–45	400	11½	9½	15½	140
21M.	25–35	1–35	310	11½	9½	13	125
15M.	16–25	1–25	240	11½	9½	9	80
21 P.	16–20	1–20	175	8½	7	13	68
17 P.	10–16	1–16	140	8½	7	10½	52
11 P.	6–10	1–10	90	8½	7	7½	34

Two interesting installations have recently been made with these batteries, which are illustrated herewith. Fig. 4 gives a view of the installation at Prof. Elisha Gray's laboratory at Highland Park. The current is utilized in lighting Prof. Gray's residence, and for experimental purposes.

Fig. 5 illustrates an installation at the factory of the Western Electric Company, Chicago. The current is employed in supplying a number of 50 volt incande-

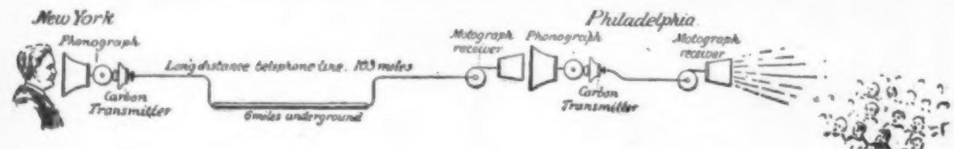
scent lamps in the offices at times when the workshops and engines are shut down.

The Detroit battery has been very favorably received, and a large number of cells have already been put upon the market, one order of no less than sixteen thousand cells having been booked from an Eastern traction company, as has already been mentioned in these columns. The Woodward company is a solid and enterprising concern, and the battery will be vigorously pushed to the front.—*Western Electrician.*

REMARKABLE EXPERIMENTS WITH PHONOGRAPH AND TELEPHONE.

ON the evening of Feb. 4, Mr. William J. Hammer, the well-known expert, delivered a lecture on "Edison and His Inventions" before the Franklin Institute, Philadelphia. This remarkably able lecture was replete with interest, and described in sequence all of Mr. Edison's inventions in the field of telegraphy, telephony, phonography, electric lighting, etc., all of which were made clear by a wealth of illustrations and experiments.

Perhaps the most striking experiments shown were those in connection with the telephone and phonograph, and consisting in the recording and transmitting of telephone conversation, music, etc. The first experiment undertaken was the recording on a phonograph in Philadelphia of music and talking transmitted over the long distance telephone line from New York, and reproducing the same to the audience.



EXPERIMENT IN PHONOGRAPHIC AND TELEPHONIC TRANSMISSION.

Another experiment consisted in recording music and talking upon the Philadelphia phonograph which had been talked into the long distance telephone by a phonograph in New York.

The most important test was that which is illustrated diagrammatically in the accompanying sketch. This consisted in reproducing to the audience, by means of the Edison motograph receiver or loud-speaking telephone and the Edison carbon transmitter, the music and talking registered on the Philadelphia phonograph and which had been sent over the long distance telephone line from New York (a distance of 103 miles) by the New York phonograph talking into a carbon transmitter. This wonderful experiment, as will be seen, employed two phonographs, two carbon transmitters, and two motograph receivers acting in juxtaposition with 103 miles of telephone wire, six miles of which was underground.—*Elec. World.*

[Continued from SUPPLEMENT, No. 687, page 10980.]

LIGHT AND COLOR.*

By Captain W. DE W. ABNEY, C.B., F.R.S.

LECTURE II.

IN the last lecture I finished the matching of the color of pigments with parts of the spectrum, and to-night I will endeavor to show you that colorless bodies can be made colored, under certain conditions, although the light that falls upon them is colorless. I told you last time that the waves of red light are such that if you put 38,000 end to end, they make up an inch. If in the sea we have two sets of waves, one set of which is exactly half a wave behind the other, then the crest of the one wave will exactly fill the trough of the other, and instead of motion we shall have rest. Suppose I have a colorless body, whose thickness is comparable with a wave of red light, and that a wave of red light when reflected from the back surface is half a wave length behind that reflected from the front surface, we get darkness instead of light. The easiest way to obtain a colorless body, answering to the above conditions, is to use a soap film stretched across a vertical aperture. Its thickness is found to be comparable with a wave of light, and as it gradually thins by gravity, some part of the film becomes of the thickness that the reflection from the back surface is half a wave length behind that reflected from the front surface, the red is annihilated at such place. There will be another thickness of film in which the green light would be similarly absent, and yet another in which the blue is absent, and so on. The light reflected from the first locality would be the components of white less the red, in the second the same less the green, and in the third the same less the blue.

I can show you the kind of color that is seen by the suppression of one small part of the spectrum, by using our patch-forming apparatus and passing a thin rod along the spectrum, which cuts out the part required. It will be seen that the patch is no longer white, but colored. These colors, remember, are not simple colors, but white light, with some color abstracted.

Putting a soap film on a ring in the beam of the electric light, at an angle of about 45° with it, the light is reflected on the screen, and a lens in the beam forms an image of the ring. At first the film appears white, but after a short interval of time, colored bars appear horizontally across it. Putting a piece of red glass in front of the beam, we have a succession of red and black bars, the red glass cutting off all the remaining colors. A piece of green glass placed in the beam shows green bars, and so on.

The bars are brighter at the bottom of the image, which is in reality the top of the film, for the reason that the film is of a thickness of 1½, 2½, 3½, 4½, 5½, etc., wave lengths of the different colored lights as we go from the top to the bottom of it. The bars gradually widen out and become very far apart, until we see only three. I now cause a gentle current of gas to play on the film, and the colored glass being withdrawn, we get a magnificent series of colors whirling one around the other. Peacock green, golden yellow, azure blue, succeed one another, and give a most brilliant effect. All these colors are due to white light falling on a colorless body.

The next experiment is to throw a small image of the film upon the slit of the spectroscope. We see the spectrum traversed by black lines curving down from red to blue, and rapidly shifting in position. These lines show the colors which are absent in the horizontal bars of colored light reflected from the film, a section of which passes through the slit.

In this case we have a demonstration that the colors reflected from the film are not produced by any conversion of white light into colored light, but by the abstraction of certain colors from the components of white light.

In the opal we have an example of interference colors, caused by a thin layer of material of different thicknesses, which abstract a certain component of white light in exactly the same manner as does the soap film. When we have the light from the varying thicknesses close together, as we have in the reflected beam in the patch-forming apparatus, they have very much the same appearance as has the opal.

But one more example of interferences, which is very beautiful, as time will not allow me to go into the theory of the matter; suffice it to say, that if parallel lines be ruled on a surface very close together, and the beam of light be thrown on them, the "interferences" are such that pure colors are produced, and we have a spectrum.

Next, let me show you that the color of transparent bodies is also due to the abstraction of color or colors from the white light.

In a cell I have a liquid which appears green. A spectrum is formed on the screen, and in front of the slit of the spectroscope the cell is placed. You will see that the blue and most of the red is cut off, and that we only have green and a small band in the red left of the spectrum. Recombining the remainder of the spectrum to form a patch as before, we have a square of green light, and side by side with it is the patch formed by the reflected beam, which is colored by the light which has not passed through the prisms, but only through the cell and the collimator. They are both absolutely of the same hue, showing that the recombined spectrum gives the same color as the light after passing through the cell. Repeat the same with a red liquid or a blue liquid, and we obtain the same results.

A paper is colored with the green dye which I had in the cell, and I allow the patch of white light to play on it, and you see the light reflected from it is green. In the path of the *reflected* beam I place a cell containing the green liquid, and throw the patch on *white* paper. The two patches, viz., the white light on the green paper and the green light on the white paper, are the same color. The white light which penetrates coloring matter is the same in the two cases, though when on the paper itself it traverses the coloring matter twice. This leads to an important axiom, viz., that the effect is the same whether the coloring matter is in contact with the paper or at a distance from it, so long as the eye receives the light which has traversed such coloring matter. I shall immediately take advantage of this, for I wish to show you that the depth of color depends on the thickness of coloring matter through which the light passes. Of a double wedge-shaped trough, half is filled with pure water and the other half with colored water. Different thicknesses of the blue coloring matter are passed in front of the slit, and as the thickness is increased so the spectrum gets fainter in the blue than in the red.

The patch of white light is next formed, and the wedge of colored liquid is again passed across the slit, and you will see that the color deepens as it passes through different thicknesses. As this is true when the coloring matter is in front of the light, so must it be true when the coloring matter is in contact with the papers.

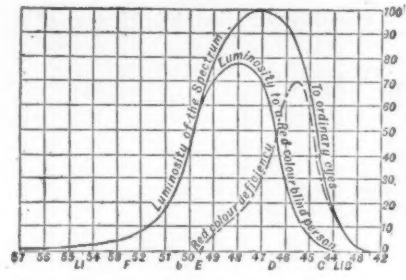
There is another feature which I must not pass over, *i. e.*, what is known as fluorescence, and though it does not enter into the effect of pigments used in water colors, yet it has much to say to the colored materials of every-day wear. One of the most beautiful examples of this fluorescence is fluorescene. In the beam of the electric light a jar of water is placed, and in it is dropped a concentrated solution of the fluorescene. We have a fine example of fluorescence; the fine threads of liquid as they stretch toward the bottom appear of a brilliant green. I take another jar and repeat the same with quinine sulphate, and we have a gorgeous blue.

We will endeavor to trace this fluorescence to its source. I take a piece of card and brush it over with the solution of fluorescene, and place it in our color patch; the different colors of the spectrum illuminate one after the other; we now can readily see the light which causes this fluorescence. It is in the green and the blue, but the light reflected from the fluorescene is of a totally different hue from the rest of the color patch. So with the quinine. We see that when the color patch is apparently dark, the paper covered with quinine shines out with peculiar luster. The rays which excite fluorescence in this case are the invisible rays in the ultra-violet. Common machine oil is fluorescent in the same part of the spectrum, but shines with a greenish light, and not blue.

We now come to the point when we must ascertain the second constant of color, viz., its luminosity or brightness. Before showing how this is done for pigments, it will be necessary to show you how we can ascertain the luminosity of the spectrum itself. The luminosity of the spectrum varies greatly in different parts, the maximum luminosity in bright lights, such as the electric light, being in the yellow, and there is a degradation of brightness as we go toward each end of the spectrum. Now suppose we find that the reflected beam of white light, when the rotating sectors are as widely open as possible, is slightly brighter than a yellow patch formed from the yellow of the spectrum—it is manifest that other parts of the spectrum will be dimmer than that. If, now, in the reflected beam, I rotate the sectors at less than full aperture, less light will reach the screen, and it is evident that there are two parts of the spectrum, one on each side of the yellow, which will match the brightness of this degraded white.

In order to make this match, we place the rod as before in front of the color patch. One shadow is thrown on the white screen by the spectrum color, and another shadow is thrown alongside it from the reflected beam. The white light and the colored light each light up one of the shadows. The slit in the card is moved across the spectrum till we find (say) that in the blue the blue illuminated shadow is too dark, and where the slit lets the green light through, the green illuminated shadow is too light. It is evident that at some intermediate place in the spectrum there the colored shadow is neither too light nor too dark. This place in the spectrum is found by moving the slit rapidly, making the colored shadow first too light and then too dark, diminishing the extent of the oscillations till equality of brightness is seen to the eye. The same procedure is carried on on the red side of the yellow. The angular aperture of the sectors is again altered, and a fresh determination made. Now, the card in which the slit is cut carries a scale, and by means of a pointer the scale is read off, which tells us the exact part of the spectrum where the different equalities of brightness are established. We then use the apertures used as giving the relative luminosities of the different parts of the spectrum as measured, and make such a curve as we have below.

FIG. 1.



The method, then, of ascertaining the luminosity of a color depends on the rapid oscillation of either the white or colored shadow between "too light" and "too dark." This gives us a clew by which we can measure the luminosity of a colored surface in a direct manner. The rotating sectors in Fig. 2 give us the means of doing this in an easy manner. Suppose the luminosity of a vermilion colored surface had to be compared with a white surface when both were illuminated, say, by gas light, the following procedure is adopted: A square space of such a size is cut out of black paper so that its side is rather less than twice the breadth of the rod used to cast a shadow. One half of the aperture is filled with a white surface and the other half with the vermilion colored surface. The light, L, illuminates the whole of these, and the rod, R, placed in such a position that it casts a shadow on the white surface, the edge of the shadow being placed accurately at the junction of the vermilion and white surface. A flat silvered mirror, M, is placed at such a distance and at such an angle that the light it reflects casts a second shadow on the vermilion surface. Between R and L is placed the rotating sectors, A. The white strip is caused to be evidently too dark and then too light by altering the aperture of the sectors, and an oscillation of diminishing extent is rapidly made till the two shadows appeared equally luminous.

FIG. 2.

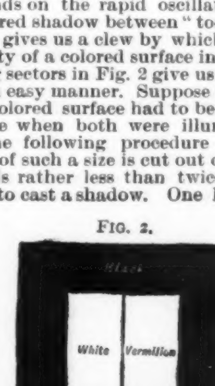
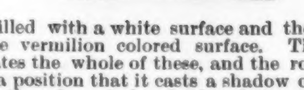


FIG. 3.



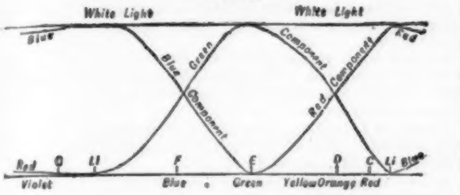
A white screen is next substituted for the vermilion, and again a comparison made. The mean of the two sets of readings of angular apertures gives the relative value of the two luminosities. It must be stated, however, that if the screen remained unshaded, as represented, the values would not be correct, since any diffused light which might be in the room would relatively illuminate the white surface more than the colored one. To obviate this the receiving screen is placed in a box, in the front of which a narrow aperture is cut just wide enough to allow the two beams to reach the screen. An aperture is also cut at the front angle of the box through which the observer can see the screen. When this apparatus is adopted, its efficiency is seen from the fact that when the apertures of the rotating sectors are closed the shadow on the white surface appeared quite black, which it would not have done had there been diffused light in any quantity present within the box. The box, it may be stated, is blackened inside, and is used in a darkened chamber. The mirror arrangement is useful, as any variation in

* Lectures recently delivered before the Society of Arts, London. From the *Journal* of the Society.

the direct light also shows itself in the reflected light. Instead of gas light, reflected sky light, the electric light, or sun light can be employed by very obvious artifices, in some cases a gas light taking the place of the reflected beam.

It will be in your recollection that I said that the color of an object depended on the eye of the observer. Vision, I have told you, depends on the fact that three color sensations are necessary for the normal eye to see white light. There are, in fact, as I have said, three sets of nerves, one responding to the blue, one to the green, and one to the red.

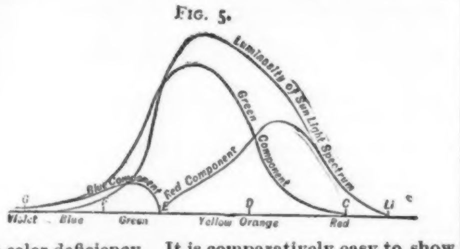
FIG. 4.



If one of these sensations be absent, then the eye does not see white light as we know it, but as—what would to us be—colored light. The above diagram shows the three sensations as determined by Clerk-Maxwell. The top line is supposed to be the spectrum as the eye sees it, all colors being of equal value. It will be noticed that at only three places in the spectrum is the color pure, and all intermediate colors are made up by mixtures of two sensations, the height of the curves added together giving the height of the straight line parallel to the base of the curve.

Now, in order to test the eye for color blindness, it is only necessary to get a person so afflicted to measure the luminosity of the spectrum. For evidently, if deficient (say) in red sensation, the spectrum would begin where the green color sensation commences, and even then the luminosity would be much smaller, owing to the absence of such red sensation. Such a luminosity curve is seen in Fig. 5, and in the same figure is shown

FIG. 5.



the color deficiency. It is comparatively easy to show the color of the light which color-blind people see. If a certain proportion of the light near the position which the blue lithium line occupies in spectrum be mixed with a certain proportion of the green light of the spectrum near E, and the two be combined in a patch, the color of the patch will be that seen by a red color-blind person. [This was shown on the screen, and the vermilion, emerald green, ultramarine, and gamboge were placed in the mixed light, and the alteration in color of the pigments noted.] In the same way the white light which blue and green color-blind see can be shown.

In measuring the luminosity of the spectrum, you cannot but have noticed that the shadow illuminated by the white light never appeared as white, but always colored. Thus, when placed in juxtaposition with the yellow, the shadow illuminated by the white light appeared bluish; when with the green, reddish; and when with the blue, yellowish. The color given to the shadows illuminated by the white light is merely the effect of contrast, and is due to error of judgment by the eye. The tendency of white in proximity to a color is to make it to appear of the hue of the complementary color, to which I shall draw attention in my next lecture.

(To be continued.)

ANALYSIS OF "TOBACCO SCREENINGS" REJECTED IN THE MANUFACTURE OF TOBACCO.

By L. P. BROWN.

THIS material consists of the small fragments of stems and leaves which with the dust are sifted from tobacco after it has been ground, in the process of preparing smoking tobacco.

Much of this substance is mixed in certain manufactured fertilizers, and is not unfrequently applied directly as a top-dressing to grass, etc.

The sample examined was taken from a lot of the screenings shipped from Lynchburg, and afforded the following:

Water lost at 100° C.	10·27
Total (crude) ash	43·40
Organic matter (by difference)	46·33
	100·00

IN THE ORGANIC MATTER.

Nicotine	0·36	
Albumenoids and nitrates	6·96	
(Total nitrogen) equivalent to ammonia		1·48

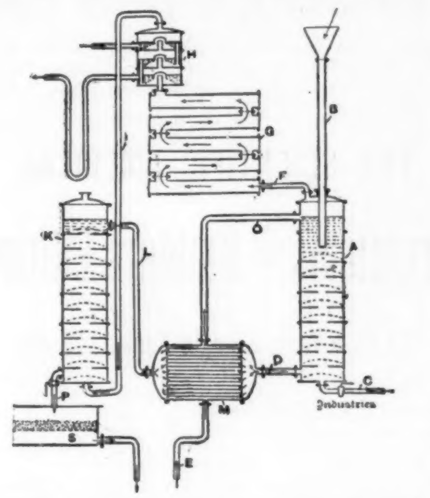
Constituents of the ash:	In 100 Parts of Screenings.	In 100 Parts of Ash.
K_2O	1·187	2·89
Na_2O	0 506	1·23
CaO	2·796	6·81
MgO	0·346	0·84
Al_2O_3	0·192	0·47
Fe_2O_3	0·212	0·52
SiO_2	33·760	82·32
P_2O_5	0·296	0·72
SO_3	0·483	1·14
Cl	0·451	1·10
SiO_2, soluble	0·907	2·21
Deduct O, equiv. to Cl	.....	0·25
	41·186	100·00

In estimating the value of this substance as a fertilizer, we must consider the nicotine, which acts as an insecticide, in addition to the organic matter and the plant food ingredients. As to the latter and the nitrogen, there is contained in 2,000 pounds, reckoning at present commercial prices, potash, phosphoric acid, and nitrogen to the value of six dollars.—*Amer. Chem. Jour.*

BICARBONATE OF SODA.

E. SOLVAY, Brussels.

IN the manufacture of bicarbonate of soda by the ammonia process, it is difficult to prevent the bicarbonate from being intermixed with a certain amount of ammonia. The inventor has designed an improved method and apparatus for removing this and other impurities in the bicarbonate. The crude chemical is dissolved by means of steam, and the solution is heated to the temperature of 35° C. The result of the heat is that the ammonia and carbonic acid is evaporated, and a pure solution of carbonate of soda is left behind. The gaseous distillate is conveyed to a chamber where the ammonia is deposited and the carbonic acid purified, and the latter is afterward forced through the cooled solution of carbonate. In this way the same carbonic acid is taken up again to form bicarbonate. The apparatus which is employed is illustrated in the accompanying figure. The crude bicarbonate is introduced through the inlet, B, into the vessel, A, and the steam



is allowed access through the pipe, C. Another inlet is provided at O, for the entrance of water or of mother liquor containing impure bicarbonate, which is to be treated in the same way. The gases which are evolved by the decomposition of the bicarbonate are led through the pipe, F, to a refrigerator, G, and afterward to the washing apparatus, H. The purified gases proceed along the pipe, I, to the bottom of the cylinder, K. The liquor which remains in the chamber, A, is sent through the pipe, D, to a refrigerator, M, where it is cooled by the action of the entering stream of water or mother liquor which passes through the pipes, E, O, The cooled solution of carbonate is passed into the upper end of the cylinder, K, where it is treated with the purified carbonic acid, and transformed by it into bicarbonate again. The bicarbonate which is thus formed is drawn off through the pipe and sent through the filter, S. The bicarbonate is deposited in this tank, and the mother liquor finds its way out, to be used for the same purpose in future operations.

RECOVERY OF AMMONIA AND CHLORINE IN THE AMMONIA SODA PROCESS.*

By FRED. BALE.

WHEN ammonium chloride is volatilized, and the vapor passed over or through heated metallic oxides at a temperature of about 400° C., 25 to 50 per cent. of the ammonia evolved is decomposed. If, however, the ammonium chloride be intimately mixed in powder with powdered oxide of manganese, on heating the ammonia is gradually and completely evolved at a temperature of 130° C. to 325° C., without the loss mentioned above after the evolution of the ammonia.

Cold or dry air can be drawn over the heated residue, which can in this way be entirely freed from any moisture or undecomposed ammonium chloride. Air may also be passed through the retort throughout the whole operation, and thus prevent any leakage, and at the same time reduce the decomposition to a minimum. Nickel oxide, when substituted for oxide of manganese, causes the ammonia to be freely given off at about 325° C., and after the passage of the air chlorine comes off at about 500° C. Other oxides require a much higher temperature for the evolution of the chlorine.

The percentage yield of chlorine is (with few exceptions) about one and a half times as great when a peroxide is used as when a monoxide is used at the same temperature. The sesquioxides yield, as a rule, about one-third less ammonia than would be expected from theoretical considerations, the remaining third being resolved into nitrogen and hydrogen. Oxides which by this process are converted into sesquioxides may, by reduction with charcoal or small coal, be obtained in a form which will then give the same equivalent of ammonia as at first.

The author proposes to use this process in connection with the ammonia soda method for preparing bicarbonate of soda, and thus prevent the loss of chlorine as chloride of calcium, which has little commercial value. He is also of opinion that there would be a large saving of labor and fuel in the manufacture of ammonia. He claims by his method of mixing the oxide or oxides with the ammonium chloride the advantage of being able to readily expel the whole of the ammonia present at a low temperature.

* Abstracts of papers—British Association for the Advancement of Science.

It differs also in the movable character of the oxide or oxides used, and the low temperatures employed throughout, and in the use of atmospheric air for the expulsion of the ammonia and steam from the retort. Trimanganic tetroxide, or any other oxide of manganese except the sesquioxide, or magnesia, or a mixture of these two, seem to give the best results. An ordinary Stourbridge fire clay retort is employed. It is important for the successful carrying out of the process that the temperature of the retort be increased gradually, and as soon as the evolution of ammonia has ceased, there is a distinct pause in the reaction. It is also essential that the moisture be removed by the passage of dry cold air over the heated residue before the chlorine, which is subsequently evolved, is led into the bleaching powder chambers.

The chlorine is evolved as soon as the temperature is raised to a dull red heat, and dry and hot air is substituted for the cold air. If the air be carefully passed, chlorine to the extent of 9 to 12 per cent. of the issuing gases is evolved when manganese is the oxide used. The residue, after all the chlorine has been evolved, is practically equivalent when reduced to the oxide originally used, and can be used for a subsequent charge, making the process a continuous one. It is necessary, however, for this residue to be removed from the retort at intervals of about a week, and washed with common salt if that body is present in the ammonium chloride.

Except for this impurity, the retort need not be opened, as the ammonium chloride is thrown in at the mouth of the retort and mixed at once with the oxide by shutting the door of the furnace and causing the scarifier to revolve. If the retort be heated by a self-feeding and practically automatic coke furnace, with properly arranged flues, the initial temperature can be obtained by the workman placing a mercurial thermometer through the door of the retort from time to time. The proportion of sal-ammoniac to oxide which is found to give the best yield is one of the former to four of the latter. This composition of the mixture insures the complete decomposition of the chlorides or oxychlorides, and also prevents any fusion of the chlorides or caking of the retorts.

Besides the oxides above named, other heavy oxides and oxides of the alkaline earth metals may sometimes be used with advantage. The salts of these oxides have also been used with satisfactory results, and also the different varieties of clay when purified from iron.

Of these substitutes, cobalt oxide alone, or mixed with magnesia, appears to be the best in giving the equivalent of ammonia, and in the ease and low temperature at which the chlorine is evolved. Magnesia reacts somewhat on the retort when one of fire clay is used. Cobalt chloride is also slightly volatile, while nickel oxide requires a higher temperature for the evolution of the gases, although it has the advantage of existing as a monoxide at a high temperature, and therefore needs no subsequent reduction.

The manganese oxide, and also some of the other oxides above mentioned, after several operations, become oxidized to sesquioxide, and thus cause a loss of ammonia if not reduced by coal. The reduction is effected by shutting off the air supply, and adding small coal to the extent of about one-fiftieth the weight of the oxides used. The gases from a coke furnace may also be passed over the residue when it is more convenient to effect the reduction by their use.

The fire clay retorts which Mr. Bale recommends are of special manufacture, and are made sufficiently nonporous to prevent the ammonia passing through them into the fire. They are worked in series, and are connected with a supply of air, which is drawn through them by an exhauster during the evolution of the ammonia, and by a blower when the chlorine is evolved. In order to control the temperature as far as possible, the retorts are heated either by coal gas or, as mentioned above, by a self-feeding coke furnace.

The retorts are set horizontally, and are fitted with covers at each end, with pipes for the passage of the gases. In the preparation of bleaching powder with the dilute chlorine, the author has found that the action on the lime is sufficiently energetic, while at the same time the temperature does not appreciably rise.

The disadvantages arising from the use of ammonium chloride containing small quantities of sodium chloride on a large scale are obviated by previously subliming the salt, the additional expense of this operation being more than compensated by the several advantages gained.

PROPOSED INTERNATIONAL STANDARDS TO CONTROL THE ANALYSIS OF IRON AND STEEL.

By Professor JOHN W. LANGLEY, University of Michigan, U. S. A.

IT is well known that the results of chemical analysis will differ slightly with the methods employed and with the personal peculiarities of the operator. This latter has been called the "personal equation" of the analyst.

These causes of variation are of great importance in all investigations where minute quantities of foreign bodies have to be sought in large amounts of a compound or mixture such as all samples of commercial iron and steel. In this class of analyses, the percentages of carbon and phosphorus are often as low as 0·15 per cent. and 0·01 per cent. respectively, and yet these small amounts will have quite marked effects in the steel which contains them.

In order to bring about a greater uniformity of analyses in the countries which are the principal producers and users of iron and steel, it is proposed to prepare a quantity of samples which shall be absolutely identical, and to distribute them to properly qualified analysts in those countries, who will then analyze them and will interchange reports of their results with each other.

By the above plan, there will be in each country participating in the work a quantity of metal identical with that in the other countries, and which has been analyzed with the utmost care by a considerable body of chemists, so that its composition may be said to be known authoritatively and beyond dispute, and which will thus constitute international standards.

The standards so obtained should serve two important purposes. First, they would show, in the course of their preparation, the relative agreement in the

processes and results habitually arrived at by the chemists of different countries, and it may be that, in addition to determining the "personal equations" above referred to, national differences, or differences due to the teaching in different chemical schools, may in this way be noticed. Secondly, these standards being distributed to certain custodians, it may be possible to furnish small portions of them to chemists who may make the necessary application, for the purpose of checking their individual work, and obtaining a measure of their accuracy. Also as new analytical methods are constantly being invented, it will be of great advantage to have a standard metal on which to test them.

The details of the best methods of securing the above ends should be the work of a committee, whose recommendations would form a preliminary standard set of processes; but it is not proposed to fix any definite methods of analysis. Professor Hermann Wedding, of Berlin, Professor Richard Akerman, of Stockholm, and Professor Langley, of the United States, have already considered the general plan, and have given provisional assent to it and to the following suggestions:

(1) The analysis shall be made for the total carbon and for the phosphorus. This is all which it is advisable to demand; but other elements may be added at the wish of any of the analysts for the samples in their hands only.

(2) The samples shall be of the following composition (or temper) in carbon, as nearly as is practicable: Carbon = 1·3 per cent., 0·8 per cent., 0·4 per cent., 0·15 per cent.; and all the other elements shall be kept down to the customary proportions for steel of medium quality.

(3) The samples shall be in the form of drillings, uniformly and carefully mixed, and quantities not less than ten kilo. for each temper; this would mean not less than forty kilo. for the whole.

(4) These samples shall be equally divided, and sent under seal to properly accredited persons in Sweden, Germany, England, and the United States.

(5) The analysis shall be made in each country independently, and the report of the results obtained shall be sent to each of the proper representatives of the other countries participating in the proposed plan.

(6) If there should be important disagreement between these reports, it shall then be the duty of the parties to this agreement to appoint an international committee, to whom the whole subject shall be referred. If, however, the reports differ only slightly, then the average of all the reports shall be deemed the true composition of the international iron and steel standards.

We understand that a committee of the British Association, consisting of Professor Roberts-Austen, F.R.S., Mr. Thomas Turner, and Professor Langley, has been appointed to make the necessary arrangements and communications with other nations for bringing the proposed scheme to their consideration, with a view to its final adoption.

THE ACTION OF LIGHT ON WATER COLORS.

By ARTHUR RICHARDSON, Ph.D.

THE conflicting statements made by different experimenters on the action of light on water colors appear to be due in a great measure to variations in the purity of the paper, in the nature of the medium with which the paint is mixed, and in the varying external conditions under which the plant is exposed.

In the author's experiments Winsor & Newton's moist water colors were exposed on Whatman's paper to sunlight in closed jars, the air in which was dried by means of calcium chloride, or kept moist by the addition of a few drops of water.

He divides the colors into two groups: (1) Those which are capable of oxidation, such as the sulphides (with the exception of vermilion and indigo); and (2) those which are reduced by light independently of atmospheric oxygen, and in some cases also of the moisture present, *e. g.*, Prussian blue, vermilion, chrome yellow, and lake.

Chrome yellow, if exposed to light in moist air, loses its color entirely in two weeks; but in dry air or carbon dioxide gas there is no change. This loss of color was proved by special experiments to be due to the conversion of the sulphide to sulphate. Long exposure of the paint to light in winter was found to produce little or no effect, pointing to the conclusion that the oxidation is brought about by the rays at the extreme violet end of the spectrum.

Cadmium orange appears to be a far more stable color than the yellow modification. King's yellow, the paint made of arsenic trisulphide, was bleached in moist air in three weeks, but was unacted upon in dry air. The sulphide itself is very sensitive to light, and was entirely bleached after one day's exposure in moist air. The chemical change in this case appears to be the oxidation of the sulphide to the oxide, as some soluble arsenious compound was found in the sulphide, which had been exposed to the light for a prolonged period, and traces of sulphuric acid were also detected.

Indigo is stable in dry air and carbon dioxide; but in moist air the paint fades rapidly on pure paper, while the presence of size or gum rendered it much more permanent.

Among those paints which lose their color by exposure in sunlight, Prussian blue is the most important. In an atmosphere of carbon dioxide, sunlight reduces Prussian blue to the white ferrous ferrocyanide, which regains its color when exposed to the air even in the dark. In air the reducing effect is retarded, and varies with the nature of the light, the bleaching going on much more rapidly in the diffused light of winter than in summer.

When mixed with cadmium yellow, the green mixture is very sensitive to light in moist air. The blue color rapidly fades in diffused light, but is restored on exposure to sunlight. The final color is true blue, as the yellow cadmium sulphide of the original green has faded by oxidation. Cadmium sulphide acts similarly on Prussian blue, while vermilion exercises a protecting action on the blue.

Vermilion mercuric sulphide, when exposed to moist air, at first darkens and then bleaches. In dry air the same changes take place, only more slowly, while in an inert atmosphere they are more rapid. The change is also hastened if the paint is exposed on sized paper.

When cadmium yellow is mixed with this paint, the orange so produced becomes almost black in a few hours, even in diffused daylight, the original color being restored in the dark; but after a long exposure, permanent bleaching takes place. Vermilion contaminates cadmium yellow even when not in contact with it in moist air, the latter turning brown.

The following colors were also examined, with the results appended, after four weeks' exposure to sunlight: Crimson lake faded entirely in both moist and dry air; Indian yellow faded slightly; gamboge faded slightly in moist air, but was unacted upon in dry air; Naples yellow bleached in two weeks in moist air; no change in dry air; cobalt, light red, Indian red, yellow ocher, raw sienna, and burnt sienna resisted the action of light in dry and moist air. Vermilion, lake, and Indian yellow are the only three colors which the author has found to fade in dry air. He recommends the use of India rubber dissolved in benzene as a substitute for glue, in order to insure a dry atmosphere after the picture is glazed and grained. He also suggests an airtight frame, with some desiccating agent such as asbestos and calcium chloride, to make all pictures proof against the prolonged action of light.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. BIOGRAPHY.—Sir WILLIAM THOMSON.—A short review of the life of the eminent physicist, with portrait.—1 illustration.......... 10988

II. CHEMISTRY.—Analysis of Tobacco Screenings Rejected in the Manufacture of Tobacco.—By L. P. BROWN.—Analysis of a waste product, with a view to determining its value as a fertilizer........ 10997
Proposed International Standards to Control the Analysis of Iron and Steel.—By Prof. JOHN W. LANGLEY.—A suggestion in the direction of standardizing commercial analysis........ 10997

III. CIVIL ENGINEERING.—Brick Street Pavements.—A plea for the return to brick for paving purposes, with instances of its actual use on highways for periods of many years' duration........ 10992
Jandin's Hydro-pneumatic Dredger.—A valuable improvement in dredging, with great capacity for removing solid obstructions.—6 illustrations........ 10988

IV. ELECTRICITY.—The Detroit Storage Battery.—A new storage battery described and illustrated, with a full table of capacity of different sized cells.—5 illustrations........ 10994

V. LITHOLOGY.—The Microscopical Investigation of Rocks.—By Dr. HENSOLDT.—An interesting and popular exposition of the recent methods of lithological study........ 10984

VI. MECHANICAL ENGINEERING.—The Governing Proportions of Steam Boilers.—By CHAS. E. EMERY.—The second and concluding installment of this important treatise, with very full illustrations.—26 illustrations........ 10990

VII. MISCELLANEOUS.—Census of the Defective Classes.—Census statistics of the blind, the deaf and dumb, the idiotic, and the insane, with analysis of the figures presented........ 10986
The Earthquake at Ban-dai-san, Japan.—A full description of a late earthquake in Japan, one of the most important of recent times........ 10985
The Samoan Islands.—An account of the personal characteristics of Samoans, and work of civilization there.—4 illustrations.... 10983
The Samoan Islands.—A general review of the topography of the islands, their fauna and flora.—2 illustrations........ 10983

VIII. NATURAL HISTORY.—The Golden Fronted Woodpecker.—By E. M. HASBROUCK.—An interesting and graphic monograph on the Texan bird.—1 illustration........ [illegible]

IX. NAVAL ENGINEERING.—Propeller for Pleasure Boats.—A new type of propeller, acting somewhat on the principle of sculling.—2 illustrations........ 10989
The Light Draught Steamer Burma.—A new steamer for use on the Irrawaddy.—Her dimensions and general features of construction.—1 illustration........ 10989

X. PHYSICS.—Light and Color.—By Capt. W. DE W. ABNEY.—Continuation of this interesting series of lectures, treating of phosphorescence and other phonomena of the eye.—5 illustrations........ 10986
Remarkable Experiment with Phonograph and Telephone.—A curious experiment in phonography and telephony recently performed before the Franklin Institute by Mr. WILLIAM J. HAMMER.—1 illustration........ 10986

XI. TECHNOLOGY.—Bicarbonate of Soda.—By E. SOLVAY.—A method and apparatus for removing ammonia from bicarbonate of soda produced in the ammonia soda process........ 10997
Coca.—Note on the history of coca........ 10987
Figue.—The growth of the American aloe in Colombia, with statistics of its uses and production........ 10997
Recovery of Ammonia and Chlorine in the Ammonia Soda Process.—By FRED BALE.—A very interesting improvement in the new soda process, leading to an economy of manufacture........ 10997
The Action of Light on Water Colors.—By ARTHUR RICHARDSON, Ph.D.—Definite experiments with standard water colors in order to ascertain with accuracy their stability when exposed to light........ 10998
